Scoliosis Research Society

Defined Non-Operative Spine Care for Adults with Spinal Deformity

Created by the SRS Non-Operative Management Committee and Outside Experts

A literature-based manual that defines areas of research and outlines the levels of care to be actively implemented in each domain known to affect pain and impact the outcomes of surgery. The manual is broken down into three sections 1) Recommendations, 2) Discussion, and 3) References and is intended for physicians and ancillary providers.

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INTRODUCTION

Effective non-operative treatments for spinal problems have been well-defined for decades. There are multiple variables unique to each patient that must all be defined and actively treated to ensure the optimum surgical outcome with minimal complications. These recommendations are based on the work of sub-groups comprised of volunteers from the Scoliosis Research Society's Non-Operative Management Committee 2018-2020 and the assistance of outside experts. The following domains have been defined and are based on a reasonable literature search.

Current Non-Operative Spine Care Definitions

If a research paper compares surgery to non-operative care, then the care must be defined. The following definitions of care are:

1. Structured Organized Care: all the variables that affect pain and function relevant to a given patient have been defined and treated
2. Partially Structured Care: all the variables are defined, but not all of them have been addressed. To qualify as partial care, all the issues have to be defined and then the treated variables must be presented
3. Random/Non-Care: the patient's variables have not been delineated or if they have, are not described in the research paper. Treatments or "usual care" are random interventions.

These recommendations are relevant only for elective surgery.

Defining Structured Non-Operative Care

In order to define Structured Non-Operative Care, we need to address the following areas concerning non-operative care prior to suggesting or performing spinal deformity surgery in adults.

1. Current Status of Defining Non-Operative Care
2. Indications for Surgery vs. Risks
3. Education
    a. The Neurophysiological Nature of Chronic Pain
        i. Principles Behind the Solutions
    b. Shared Decision-Making
        i. Understanding How the Overall Prehab Improves Outcomes and the Risk of an Ignored Hyper-Sensitized Nervous System
4. Sleep
5. Physical Factors
    a. Conditioning
        i. Physical Therapy
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    c. Osteoporosis
6. Stress

    a. Anxiety/Anger
        i. Depression
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    b. Situational
        i. Disability/ Medical Legal Issues
        ii. Social Isolation
        iii. Abuse
        iv. Personal Losses
        v. ACE (Adverse Childhood Experiences) Impact
7. Medications
    a. Opioids
    b. ETOH
    c. Substance Abuse
    d. Anxiolytics
    e. Others
8. Medical Optimization
    a. DM
    b. Cardio/Pulmonary
    c. Liver/Bleeding
    d. Renal
    e. Nutrition

SECTION 1: RECOMMENDATIONS

Recommendations for non-operative care prior to proceeding with adult spinal deformity surgery.

Current Status of Defining Non-Operative Care

No papers in the adult spinal deformity surgery literature present a fully defined non-operative care program reflecting literature-based recommendations to be implemented before considering surgery. Only a few document a partial level of pre-operative interventions.

1. Patients should be counseled regarding the factors that affect surgical outcomes and a systematic approach should be implemented prior to recommending surgery.
2. Patients should be educated regarding the lack of standards defining adequate non-operative care prior to proceeding with surgery.
3. Future research should develop a standardized template of the factors to be addressed and documented to define adequate care.
4. "Failure of non-operative care" is term that should be discarded until there is a solid consensus of how it should be defined.

Indications for Adult Deformity Surgery vs. Risks

What does the literature say are the indications to perform adult spinal deformity surgery?

Indications

1. Pain
    a. Axial pain is not an indication for surgery
        i. "Failure of non-operative care" – no paper has defined non-operative care so there is nothing to "fail"
        ii. If a paper wishes to use these criteria, then the specific interventions must be defined.
2. Neurological deficit/radicular pain
    a. Matching compressive lesion
    b. Patients more likely to proceed with surgery
    c. Should probably include a fusion
        i. One level or the whole deformity is unclear
3. Magnitude of the deformity
    a. Scoliosis: Threshold for severity of curve has not been established in adults
    b. Kyphosis: Threshold for severity of curve has not been established in adults
4. Truncal imbalance
    a. Sagittal imbalance >50mm in full-length, weight-bearing lateral radiograph (Daubs)
    b. Coronal

        i. Better tolerated than sagittal imbalance
        ii. Number of mm imbalance not been documented.
        iii. May not be an indication for surgery.
    c. Spinopelvic imbalance: not a documented indication as an isolated indication
5. Progressive deformity - parameters have not a documented for surgical intervention.

Risks

The most important long-term significant risks of ADS (most common and severe) are:

1. Pseudarthrosis (5 to 27%),
2. Residual pain (5-15%)
3. Junctional breakdown (25-35%)

The most important short-term significant risks of ADS (most common and severe) are:

1. Neurologic injury (1 to 5%),
2. Infection (0.5 to 5%),
3. Thromboembolism (1 to 20%)

The most significant catastrophic risks of ADS surgery are:

1. Definition
    a. Requiring 3 or more return trips to the OR
    b. Blindness
    c. Complete paralysis/ or Loss of B&B function
    d. Major stroke
    e. Death
2. Odds of any of these occurring has not been well delineated.

Overall risk of major short and long-term complications is around 40%-50% for minor complications. The category of catastrophic complications needs to be further defined. The key is that several detailed discussions are needed with the patients for them to comprehend the magnitude of the surgery and the potential impact on their quality of life. It is one of the main reasons that surgical decisions should not be made on the first visit.

Education

1. All patients should be assessed for significant multiple system physiologic distress. A comprehensive history and review of symptoms is imperative and should be taken through the lens of physiologic distress. Physiologic distress and a chronic threat/stress response may be the mediator of chronic pain and is also a strong indicator of risk for complications and poor outcomes associated with surgical intervention.
2. Regardless of the original source of pain, pain becomes centralized within 6 to 12 months. (Hashmi)
    a. The diagnosis of centralized pain can be made carefully using assessment tools as discussed below. (Schubiner, Abbass) All patients should be assessed for centralized pain, regardless of the original source of pain.

    b. The diagnosis of centralized pain can be made carefully using assessment tools as discussed below. (Schubiner, Abbass)
3. Chronic pain is complex multifactorial biopsychosocial problem involving the neurologic, immunologic, endocrinologic, psychologic and sociologic systems. All factors must be addressed in order to successfully resolve the chronic pain. It has not been documented that a compensated spinal deformity is a significant factor in contributing to chronic neck and back pain.
4. Any procedure performed in the presence of severe physiologic distress and/or untreated centralized pain, has a minimal chance of success with more complications. There is a significant chance of worsening chronic pain and exacerbation of a pain syndrome should be considered a complication of surgery that has its error in the preoperative assessment and treatment phase. (Ballantyne, Perkins)
5. The decision to proceed with adult spinal deformity surgery should not be made until the physiologic distress and the chronic pain component is addressed and solved. Surgery should be performed for neurologic impairment or disabling deformity and not for pain.
    a. The process of calming down the threat/stress response of the body should be actively pursued for at least six months prior to surgery in addition to other conditioning and rehabilitation measures
6. Complete healing involves multiple levels of the nervous system including brainstem structures mediating the autonomic nervous system, subcortical brain structures that mediate hormonal and neurotransmitters influences, and older and newer cortical structures that modulate these systems.
7. It can't be overstated that the less well understood subconscious brain running predictive codes for safety and danger, housing physical and emotional traumatic memories, and holding suppression and repression energy all can activate threat/stress physiology and pain pathways. Further research in these areas is needed to fully understand the implications of the subconscious and its relationship to illness, disease, pain and the risk of surgery.

Sleep

Sleep is a critical factor affecting the perception of pain.

Desired Outcome

1. Consistently sleeping at least six cumulative (but not necessarily consecutive) hours during a 24-hour period for a minimum of six weeks.

Evaluation

1. Validated brief sleep questionnaire – if sleep not an issue then no further action is required.
2. Screening questionnaires for:
    a. Disordered sleep breathing (sleep apnea)
    b. Restless legs
    c. Mood disorders

The two major sleep disorders, sleep-disordered breathing and restless leg syndrome must be ruled in or out and other disordered sleep diagnoses considered. Insomnia, difficulty initiating, maintaining, and resuming sleep is an additional symptom and must be treated regardless of the cause. Identifying the reasons will help guide the treatment plan.

Treatment

1. Tailored to the relevant findings of the above-mentioned assessment questionnaires.
2. See sleep section (p. 87) for the literature support.
3. Includes:
    a. Sleep hygiene
    b. Over-the-counter medications
    c. Expressive writing
    d. Address situational stressors
    e. Acknowledge role of elevated ACE (Adverse Childhood Experiences)
    f. Prescription sleep medications
    g. Evaluation by a sleep specialist if no resolution or a disorder diagnosed.

Consistently obtaining restful sleep is a necessary aspect of the treatment of chronic pain and must be solved before pursuing surgical interventions. The rest of the rehab process is of limited effectiveness without adequate sleep.

Physical Factors

Physical Therapy/Conditioning

Guided physical conditioning and implemented physical therapy is one of the cornerstones of spine care, however, specific protocols concerning spinal deformity have not been extensively studied and those that are available, lack long-term follow-up. Further research is needed, and until such time that there is greater evidence on the efficacy of specific intervention, the following is recommended.

Treatment for adults with symptoms due to spinal deformity should reflect the specificity of their movement dysfunction and physiological impairments; these individuals should not be grouped into categories of individuals with low back pain. They should be referred to a physical therapist who possesses expertise in the care of individuals with adult deformity, and who incorporates the following:

1. Thorough examination that evaluates the correlation of movement dysfunction and symptom reproduction as well as physical impairments, such as limitations in ROM and strength.
2. Development of an intervention program that addresses impairments with intervention that is best practice, such as physiotherapeutic scoliosis-specific exercise (PSSE), motor re-education, and cognitive rehabilitation.
3. Intervention that includes instruction in ergonomics and activities of daily living (ADL) and reflects PSSE philosophy.
4. Maintenance of close communication with the spine team determining measurable and objective goals for each patient in order to determine the success or failure of non-operative care.

For individuals with hyper-kyphosis who are referred to a physical therapist, the following should occur:

1. Thorough examination that evaluates the correlation of movement dysfunction and symptom reproduction as well as physical impairments, such as limitations in ROM and strength.

- Hips should be specifically addressed, including x-rays. Arthritis and/or flexion contractures may be a significant component of the kyphosis.

2. Development of an intervention program that addresses impairments with intervention that is best practice, and stresses thoracic trunk extension and strengthening and avoids thoracic flexion.
3. Intervention that includes ergonomic and ADL instruction that avoids activities that stress thoracic flexion.

Smoking

1. Assessment
    a. Non-smoker
    b. Former smoker
        i. How intense and for how long?
        ii. When stopped
    c. Current smoker
        i. Number of pack years
2. Patient education – smoking effects on spine fusions
    a. Compromised wound healing
    b. Higher intra-operative blood loss
    c. Increased odds of a pseudarthrosis
3. Discontinue smoking prior to adult deformity surgery
    a. The amount of time before performing surgery to quit is not clearly defined. It is simply known that complications are less if the patient has been off cigarettes for a longer period of time.
        i. Former smoker is defined by being off of cigarettes for longer than 12 months.
        ii. Discussion of outcomes between current and non-smokers should be documented.
    b. Consider pre-op blood testing to measure compliance

Osteoporosis

Despite the large number of elderly patients undergoing spinal surgery, and the high incidence of poor bone health of these patients, a number of orthopaedic spine surgeons report that they do not routinely perform osteoporosis workups on their patients prior to spinal surgery (Dipaola 2009). In addition, even groups convened to determine international consensus on appropriate evaluation and treatment for adults with spinal deformity (ASD) have difficulty determining agreement on the appropriateness of approaches in care (Berven 2018).

Recommendations

1. All spine patients > 50 years of age should be screened to determine if DXA is indicated using National Osteoporosis Foundation and international Society for Clinical Densitometry guidelines, Table 1.
    a. DXA should include total hip, femoral neck, and lumbar spine. In cases where both cannot be used, one third distal radius is obtained.
    b. Spine patients at the time of DXA should have Vertebral Fracture Assessment (VFA) and Trabecular Bone Score (TBS) if available.
    c. The FRAX 10-year hip and 10-year major osteoporotic fracture risk should be measured.
    d. Hounsfield units about one or at locations where fusion will and should be determined if available by CT AHU <100 indicates likely osteoporosis and < 80 is associated with poor fixation
2. Patients should be counseled to consume 1,200 milligrams of calcium daily and 1,000-2,000 U Vitamin D3 daily

Documented Osteoporosis

Patients with diagnosis of osteoporosis should have further bone health assessment. Bone health is classified according to National Bone Health Alliance (NBHA) guidelines, Table 2.

1. Bone assessment includes evaluation and optimization of
    a. Secondary osteoporosis
    b. Fall risk
    c. Nutritional deficits such as malnutrition sarcopenia and vitamin D deficiency
    d. Elimination of toxins such as smoking and alcohol use
    e. Anti-osteoporotic medication where appropriate
2. Surgical delays should be considered in osteoporotic spinal deformity patients when:
    a. Undergoing fusion, osteotomy, or revision surgery,
    b. There is a history of spinal fracture or other hardware related complications.
    c. There are patient-specific risk factors such as diabetes mellitus, steroid use, and rheumatoid arthritis.
3. The duration of the surgical delay is balanced between indications for urgent treatment, severity of osteoporosis, and skeletal requirements of the surgical procedure such as deformity correction and multilevel fusion.
    a. A three-month delay surgery for one to two–level lumbar fusion and simple revision surgery.
    b. A greater delay of six to nine months for patients with severe osteoporosis (T spine lesson -3.5), presence of osteoporotic fracture, osteotomies, and long fusions.
        i. Risks versus benefits should be clearly discussed with this group as multiple procedures may be required for ongoing breakdown and hardware issues.
4. A surgeon who recognizes poor bone quality during surgery should consider assessment with DXA.

Table 1: Indications for DXA in Evaluation Of Revision Spine Surgery Patients[27]
Women over age 65
Men over age 70
History of fracture after age 50
FRAX risk if major osteoporotic fracture > 8.4%
High-risk medication use, e.g., corticosteroids
Low body weight
Revision spine surgery over age 50*
Key: *Authors opinion

Table 2: Classification of Osteoporosis National Bone Health Alliance (NBHA) Recommendations For Diagnosis Of Osteoporosis[24]
T-score <= -2.5 of hip, spine, or one-third radius <= -2.5
Hip and spine fracture low energy
Osteopenia T-score and fragility fracture of wrist, pelvis or proximal humerus
Osteopenia and high FRAX
** probability of fracture; * of proximal femur; ** Fracture risk assessment tool

Adult Deformity Bracing

1. To be differentiated from bracing for osteoporotic fractures
2. Long-term conditioning is important prior to brace consideration
3. May be considered for pain and postural support

a. Minimal wear was 4-6 hours a day for 6 months
b. Type of brace is unclear
c. Combine with long-term conditioning program

4. Requires detailed conversation with patient as compliance is erratic
    a. Not intended for correction of deformity
    b. Limited movement
    c. Aesthetics
    d. Pain relief unpredictable
    e. Decrease breathing function
    f. May need assistance putting on
    g. Abdominal discomfort/ fullness
    h. Trunk strength decreased

Long Fusions and Frailty

Frailty/Falls

1. Screening
    a. CDC – three questions:
        i. Do you feel unsteady when standing or walking?
        ii. Do you worry about falling?
        iii. Have you fallen in the last year?
    b. Office screening
        i. Timed Up and Go test (TUG) – see discussion
        ii. Grip strength – sleep
        iii. see discussion on page 57
2. Assessment – to be done by PT's for CGS Level A patients or fail above screening tests.
    a. Physical therapists should provide an individualized assessment within the scope of physical therapist practice that contributes to a multifactorial assessment of falls and fall risk. Additional potential risk factors may need to be addressed by the appropriate provider as indicated (CGS Grade A: Strong recommendation based on Level II evidence). This assessment should include:
    b. Medication review with emphasis on polypharmacy and psychoactive drugs
    c. Medical history with emphasis on new or unmanaged risk factors:
    d. Osteoporosis,
    e. Depression
    f. Cardiac disease, including signs or symptoms of cardio-inhibitory carotid sinus hypersensitivity
    g. Body functions and structure, activity and participation, environmental factors, and personal factors:
        i. strength
        ii. balance
        iii. gait
        iv. activities of daily living
        v. footwear
        vi. environmental hazards
        vii. cognition
        viii. neurological function
        ix. cardiovascular function, including postural hypotension

x. vision
xi. urinary incontinence

3. Pre and post op conditioning plan in place to be coordinated with pre-op physical therapy planning.
    a. Rigorous conditioning will improve mobility and decrease complications.
    b. Some patients may avoid surgery.

Stress

The adverse effect of anxiety, anger, depression, catastrophizing, and fear avoidance on treatment outcomes have been documented for over 50 years in many research papers. Yet a 2014 paper out of Baltimore showed that fewer than 10% of surgeons were addressing these issues prior to recommending surgery. (Young)

Assessment

1. Mood
    a. Anxiety/Catastrophizing
        i. PHQ 9?
    b. Depression
        i. What scale?
    c. Anger/Willingness to engage in treatment
        i. Anger scale?
        ii. Stages of change?
        iii. PTSD/ ACE scores
2. Environmental Stress
    a. What specific new environmental stresses have occurred in the last 18 months**?**

Treatment

1. Patient Interaction
    a. Listen to each patient's story and keep listening at each subsequent visit.
    b. Perform the history and exam at the initial visit, and further history at each visit and hands-on re-exam as needed. Remain active and engaged. These are the basic tools of our work.
    c. Allow adequate time for each visit. This is likely the single most difficult goal to accomplish in all of health care in America. It is also arguably one of the most important foundations of good care.
    d. Become familiar with the work and process of motivational interviewing to accomplish this patient-centered care and to empower patients for change. This process has the potential to empower the physician as well.
    e. Stay centered and focused in each visit and develop tools including self-awareness and attention to breathing to accomplish this goal. This will allow each of us to respond rather than react.
    f. Remember, "The patient is not the problem. The problem for which they come to see us is the problem." Develop the approach that patients often present difficulties of interaction and

personality. This does not make them "difficult patients." This orientation will help avoid uncomfortable interactions and countertransference.

g. Change and working with complex medical problems takes time. There is no time limit to the time it might take for change and healing. Once the patient comes in for the initial appointment the physician-patient relationship is established. There is no preconceived limit to this sacred trust. Do not make major surgical decisions on the first visit and with elective deformity surgery preferably making the decision jointly over 3 to 6 months.

2. Patient Education
    a. Patients whose primary complaint is pain should receive pain neurophysiology education.
    b. Pain education should be combined with *active* treatment modalities (e.g., mindfulness, CBT, and movement therapies, vs. massage, injections, and manipulation treatments.).
    c. The focus of pain education should address fears and misconceptions about pain that interfere and/or prevent patient engagement in self-directed activities. That is the purpose of pain education is NOT as a single modality intervention but used so that active and psychologically informed therapies *make sense* for the patient to perform them.
3. Engage in Expressive Writing – regardless of diagnosis
    a. Almost any form of it is reasonable – just a starting point
4. Instill a Sense of Optimism and Hope – can be done by all parties involved in the patient's care.
5. Behavioral Change/Emotional Therapy
    a. CBT
    b. ACT
    c. EAET
    d. ISTDP (Intensive Short-term Dynamic Psychotherapy)
6. Not Focusing on the Pain
    a. No pain diary
    b. No pain support groups
    c. No discussing pain with anyone but health care providers – limited and focused.
7. Forgiveness
    a. See table below for Forgiveness steps and their objectives.

Step	Objective
1	Know exactly how you feel about what happened and be able to articulate what about the situation is not ok. Then, tell a trusted couple of people about your experience.
2	Make a commitment to yourself to do what you have to do to feel better. Forgiveness is for you and not for anyone else.
3	Forgiveness does not necessarily mean reconciliation with the person that hurt you or condoning of their action. What you are after is to find peace. Forgiveness can be defined as the "peace and understanding that come from blaming that which has hurt you less, taking the life experience less personally, and changing your grievance story."
4	Get the right perspective on what is happening. Recognize that your primary distress is coming from the hurt feelings, thoughts and physical upset you are suffering now, not what offended you or hurt you two minutes – or ten years –ago. Forgiveness helps to heal those hurt feelings.
5	At the moment you feel upset practice a simple stress management technique to soothe your body's flight or fight response.
6	Give up expecting things from other people, or your life, that they do not choose to give you. Recognize the "unenforceable rules" you have for your health or how you or other

	people must behave. Remind yourself that you can hope for health, love, peace, and prosperity and work hard to get them.
7	Put your energy into looking for another way to get your positive goals met than through the experience that has hurt you. Instead of mentally replaying your hurt, seek out new ways to get what you want.
8	Remember that a life well lived is your best revenge. Instead of focusing on your wounded feelings, and thereby giving the person who caused you pain power over you, learn to look for the love, beauty and kindness around you. Forgiveness is about personal power.
9	Amend your grievance story to remind you of the heroic choice to forgive.

b. Knowing the importance of negative emotions and the role these experiences can play in exacerbating chronic pain conditions is imperative to better understand and continue to implement and evaluate approaches such as the *Forgive for Good* method in helping pain patients cope. Chronic pain patients are commonly misunderstood, treated unfairly, and ostracized and excluded from many parts of normal daily social, family, and work life. This can leave chronic pain patients with feelings of anger, injustice, resentment, and hopelessness. Finding ways to address these common experiences in a productive manner offers one-step toward better coping, daily functioning, and quality of life. Learning to forgive for (one's own) good can offer an important contribution to living a fulfilling and flourishing life in spite of challenges arising from chronic pain.

Desired Outcomes Prior to Deciding on Surgery

1. Wait out the Patient's Situational Stresses
    a. The above process will reveal what really is going on in a patient's life. It is remarkable how often symptoms will abate with time and support.
2. Anxiety and Depression should Improve and be maintained
3. Anger (most critical) blocks engagement and effective treatment. Most easily measured by willingness to engage and take responsibility for his or her own care. If actively participating in treatment, probably in a range that is OK.
    a. Conversely, if not open to engaging in own care, then elective surgery should not be an option. These patients have unpredictable outcomes.
4. Education
    a. Clinician should have a basic knowledge of the neurochemical nature of chronic pain and understand the treatment approach.
    b. This information should be transmitted to the patient as the foundational step of pursuing a multi-dimensional program to relieve pain.
5. Multi-Disciplinary Program
    a. No response or engagement with any of the above interventions

Medication Management

Opioids

Perioperative Pain Management

Chronic Opioid Use or Addiction

The patient may have significant anxiety regarding the surgery and specifically pain management. If they have had surgery whilst being on chronic opioids in the past, they may have experienced first-hand opioid–induced hyperalgesia and poor perioperative pan control.

It is important to present a clear plan to allay their anxiety. This should include:

1. Use of local anesthesia during surgery
2. Possible peri-neural or epidural catheter with instillation of local anesthetic
3. Use of non-opioid analgesics on a PRN and RTC basis for pain management and physical activities.
4. Use of opioids which the patient has stated works best for acute pain e.g., oxycodone instead of hydromorphone or vice versa.
5. Possible use of PCA if indicated for the first few days.
6. Consider using buprenorphine if you are familiar with its use or consult with a pain specialist who is adept at using this partial opioid agonist and kappa-antagonist.
7. Use of ketamine peri-and post operatively if opioid induced hyperalgesia a possibility.
8. Increase of the baseline opioids the patient is taking chronically for a time contingent basis.
    a. A time contingent plan for patient for tapering opioids back to pre-surgical levels

Ideally, a team who knows the patient should be involved in the planning. This could involve Surgeon, PT, pain specialist, psychologist, psychiatrist, sleep and chemical dependency specialists. A pre-op consultation and stabilization of opioids is desirable for patients with complex medication issues – especially if multiple medications are involved.

Minimal or No Opioid Use

If the patient is on intermittent, or no opioids at present, a careful history should be taken to ensure adequate perioperative pain management if opioids are to be used. This should include any problems with specific opioids in the past.

1. Significant side effects
2. Poor efficacy
3. Previous history of opioid addiction

Benzodiazepines/Sedative-Hypnotics

Options Include:

1. Monitored discontinuation - can be dangerous at worst and very uncomfortable at best. Requires consultation, preferably with a psychiatrist or addiction specialist who understands the nuance of detoxification and withdrawal from sedatives of this class. Risks include seizures, severe anxiety, insomnia and tremulousness.
2. Continue current treatment – any special monitoring indicated? If used in combination with opioids, monitor for respiratory depression (especially with pre-op and intraoperative anesthesia). After surgery, post-op care should not change significantly. If patient is on opioids and benzodiazepines, prognosis may be worse in terms of recovery of function, which is the primary goal of the surgery.
3. Consider substituting non-habituating drugs for sleep and anxiety – and encourage treatment of underlying conditions with CBT, DBT, mindfulness, exercise, sleep hygiene and use of alternative medications. (see list below in discussion)

Anti-Inflammatories

Pseudarthrosis Considerations:

1. May use in peri-operative period for less than 14 days at "normal doses" defined as:
    a. Ketorolac (Toradol) at a dose of less than 120 mg/day
    b. Diclofenac sodium (Voltaren) at a dose of 25 to 300 mg in all or 75 to 150 mg/day for 2 days,
    c. Celecoxib (Celebrex) at a dose of 200 to 600 mg/day,

Peri-Operative Bleeding Issues:

1. Discontinue for at least 48 hours prior to any spine surgery when concerned about:
    a. Blood loss
    b. Post-operative hematoma
2. This is in contrast to:
    a. Aspirin – stop 7-10 earlier
    b. Plavix – 10 days

ETOH

1. Ask every patient about his or her alcohol use. Be as quantitative as possible.
2. Administer CAGE questionnaire
    a. Attempts to cut down?
    b. Getting annoyed if asked about drinking?
    c. Feeling guilty about drinking?
    d. Ever taking an "eye opener" to steady nerves?

3. Suggest cutting down or quitting alcohol before the procedure. If the patient is drinking daily, he or she may have physical dependence requiring medical intervention by addiction specialist.
4. Whenever possible get collateral information from spouse, friend or children.
5. If patient is a regular drinker, observe for withdrawal post-operatively which can be managed with Benzodiazepines and close monitoring.

Other Illicit Drugs

1. Assess every patient for the use of illicit medications.
    a. There is no best way to ascertain whether the patient is engaged in illicit drug use or the extent to which this may be occurring except in the extreme (i.e. when there is clearly an impaired patient or there is drug-testing protocol in place). Some facilities engage in drug testing for all patients and, while this is a more comprehensive approach, it does present some risks to the development of a working relationship with a patient and there are high costs for testing.
    b. The National Institute on Drug Abuse will provide a resource guide for clinicians to use in the screening and testing of adult patients (www.drugabuse.gov/sites/default/files/resource_guide.pdf).
2. Develop a treatment plan for each drug.
    a. Work with your institution or community to create a resource that can incorporate addressing illicit substances into a standardized process.
    b. While this may appear to be an undertaking worthy of an entire practice, it is possible, with the assistance of support teams with nursing social work and psychology as well as pain management.
    c. An approach would be to develop a treatment plan, which includes therapy/work groups, planned reduction in medications, drug testing, and physical therapy.
    d. Recognizing the risk factors, therapies need to address mental health issues and treatment, high-risk behaviors and alternate choices, educational programs, pain management options including drug testing and focused pain management strategies.
    e. It has been demonstrated that many patients, even those with a history of nonprescription drug use, self-medication and high-risk behaviors, are more likely to be engaged when there is some understanding of the process that is causing the pain, the factors that pay into it like emotions, mental health, depression, socioeconomic issues.
    f. Active rather than passive approaches are, again, more likely to engage the patient in regular activity, monitoring and self-awareness.
3. Have a discussion regarding each medication
    a. In some cases, it is appropriate to consider having an in-depth discussion with the patient on the use of each medication, potential risk for illicit drug use, past use, current use, and pain tolerance.
        i. However, while this is a reasonable approach for some, it is time consuming and to date, we do not have a standardized approach to questioning that can fit into a short structure appointment for the assessment and treatment plan for back pain.
        ii. We do have the option of utilizing social workers, pain psychologists and nurse practitioners who are educated and skilled in collecting data and providing some support and education.
4. Do not consider any definitive invasive procedures until this area is successfully resolved or stabilized to all party's satisfaction.
    a. It is important that there be a therapeutic relationship and that the recognition of illicit drug use is addressed and monitored.

b. Patients with high-risk behaviors should be educated and, if possible, contracted to engage in treatment plans designed to address the high-risk behaviors prior to engaging in additional therapies.
c. Since there are added risks associated with the use of these medications, it is appropriate to set limits on these behaviors and establish accountability in the patient and family that is a requirement prior to the scheduling of any invasive procedures.
d. An example is knowing the risks of continued smoking. Patients who are candidates for surgery are required to be nicotine free for 8 weeks prior to the surgery and agree to be nicotine tested at the time of scheduling.
e. Similar protocols can be established in your practice that are in alignment with the goal of taking a patient who is in the best possible state to the next level.

5. Remain firm in not letting this area slide by.
    a. No one wants to invest time and resources in a patient who continues to be on disability post operatively or seeks pain medication post operatively in a non-therapeutic way or who is not willing to entertain the investment that necessary to build a relationship that is conducive to the best outcome.
    b. Of the current state of health care and the increasing burden on the provider, this is an issue that, for many, does not seem worthy of additional time. However, clarifying the issue early and guiding the patient to appropriate therapies is important if you are looking for the chances of greatest success.

Medical Optimization

The prevalence of adult spinal deformity surgery (ADS) continues to increase with the increased prevalence of the older population. One of the most common complications following any intermediate to high-risk surgery, such as ADS, is cardiac in nature. In fact, 50% of perioperative deaths are cardiac in nature, most of them occurring within 72 hours post-operatively. Hence, it behooves the deformity surgeon to assess patients undergoing adult deformity spinal surgery from a cardiac standpoint.

Diabetes Mellitus is currently an epidemic in the United States and parts of Europe and is a leading cause of death and disability in the Western world.

Chronic renal failure (CRF) is associated with hypertension and diabetes. Patients with CRF or end-stage renal disease (ESRD) are at risk for osteoporosis, electrolyte imbalances, and anemia.

Patients with chronic liver disease undergoing elective surgery are at risk for acute liver failure, which can lead to severe coagulopathy, encephalopathy, adult respiratory distress syndrome (ARDS), acute renal failure, and sepsis.[1]

Cardiac

1. Screening
    a. Revised Cardiac Index (RCRI)
        i. RCRI = 1 or less and Metabolic Equivalents (METS) are 4 or more – no more testing (possible modified Bruce Protocol treadmill)
2. Testing (if needed)
    a. EKG (even if RCRI 1 or less) for ASD surgery
    b. Cardiac echo (if not more than 6 months from a prior echo)
        i. Abnormal EKG
        ii. Possible valvular disease
        iii. Dyspnea or hint of cardiac failure
    c. Stress Testing – per cardiology based on above
        i. Can't determine functional capacity from history
3. Absolute Contraindications for Elective ASD surgery
    a. Ejection fraction less than 35%
    b. Unstable angina
    c. MI within 3 months
    d. Symptomatic moderate or severe valvular heart disease
    e. History of:
        i. Balloon angioplasty within 14 days
        ii. Bare metal cardiac stent within 30 days
        iii. Drug eluding cardiac stents within one year
    f. On Anticoagulants for Cardiac Issues:
        i. Consult cardiology for risks of discontinuing prior to surgery.
    g. Arrythmias usually OK if cleared by cardiology
4. Other Cardiac Medications to Consider
    a. Beta Blockers
        i. Continue if on chronic
        ii. Begin if RCRI 3 or higher – begin a week in advance
    b. Continue
        i. Anti-hypertensives
        ii. Statins
    c. Hold
        i. Diuretics
        ii. Lithium if levels OK
        iii. Oral hypoglycemics
        iv. Levo/ carbidopa
        v. Estrogens
        vi. ASA, NSAIDs, herbals 5-7 days prior to surgery

Diabetes

> 7% Hemoglobin A1c refer to primary care for tighter management

Renal

1. BUN and creatinine – no treatment if normal
2. Chronic Renal failure - ? definition
    a. Pre and post op potassium levels
    b. Hgb corrected to > 10
    c. Calcium, glucose and phosphorus be maintained wnl
    d. Check bone density
3. End-stage renal failure
    a. Dialysis within 24 hours of surgery
    b. Close monitoring of volume

Liver

1. Evaluation
    a. MELD score (Model for end-stage liver disease)
        i. <10 safe
        ii. 20 – significant risk of complications
    b. Childs-Pugh staging for chronic liver disease
        i. Class A – 6 or less
        ii. Class B – 7 to 9
        iii. Class C – 10 or more
2. Treatment
    a. Correct coagulopathies
    b. Optimize renal function
    c. Minimize pre-existing encephalopathy
    d. Prevent sepsis

Nutrition

1. Screening
    a. An albumin and pre-albumin should be drawn on every patient that is a candidate for elective spine surgery of any magnitude, especially deformity surgery.
2. Treatment
    a. If the albumin is < 3.5 g/ dl or the pre-albumin is < 20 mg/ dl elective surgery should be delayed due to a marked increase in mortality, infections, wound dehiscence and other complications.
    b. Referral should be made to a dietician or primary care to improve the nutritional status.
    c. The period of time this should occur over is unclear. It is critical to ensure that a patient is in a stable anabolic state. Much of this has to do with other co-morbidities.

SECTION 2: DISCUSSION

Current Status of Defined Non-Operative Care

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Almost every paper on adult deformity surgery states that the patient underwent conservative care prior to undergoing surgery. Although there are numerous effective non-operative treatments it is rarely documented what interventions were taken prior to surgery.

There are no papers documenting adequate non-operative care. Only a few papers partially define any type of non-operative care. The majority of papers looking at spine surgery either do not mention or specify non-operative interventions prior to proceeding with surgery.

Methodology
We utilized the references from two specific papers (Yeramaneni unpublished and Kelly) as our primary source for determining the current situation with regards to non-operative (NOP) prehab utilized before performing surgery (OP) on patients with Adult Spinal Deformity (ASD).

Yeramaneni's group conducted a systematic review of the current literature on the distribution of demographic, radiographic, and patient reported outcome measures (PROMs) in ASD patients receiving (OP) or (NOP) care, and how these factors influence therapeutic decision making. A total of 30 articles were included in their final analysis which they summarized by author, year, study design, number of patients in each treatment arm, minimum follow-up time, and level of evidence.

The Kelly paper is a multicenter trial with randomized and observational cohorts for Adult Symptomatic Lumbar Scoliosis (ASLS) comparing the effects of (OP) to (NOP) for primary (no prior fusion) ASD patients. This paper had a limited number of references, and we noted that the papers we selected for review were in fact included within the papers selected for Yeramaneni's systematic review.

Consequently, we focused on Yeramaneni's selected papers (Yeramaneni 2016, 2018) as the primary source for our workgroup's review. Due to an oversight, one of the papers (Molinari) was omitted from our list. In addition, the latest paper reflected in Yeramaneni's paper was in 2018, therefore, to provide a more current analysis we added two more recent ASD papers published in 2019 by Carreon and the Kelly paper.

In total, we included 31 papers for the purpose of determining the level of conservative care prior to proceeding with surgery. These papers reflect ASD treatment for 5,117 OP patients and 3,497 NOP patients. We extended the Yeramaneni data to include Journal, Citations, Type of NOP Tx Mentioned, Comments, and Scoring.

Table 1A

	A	B	C	D	E	F	G	H	I	J
1	Authors	Journal	Year	Citations	Study design	Comparison groups	NOP	OP	Follow-up	Levels of evidence
2	Acaroglu et al.	Eur J Spine	2016	2	Decision analysis	NOP vs OP	309	123	1 year	II
3	Acaroglu et al.*21*	Arch Orthop Trauma Surg	2017	2	Decision analysis	NOP vs OP	371	164	1 year	I
4	Bess et al.	Spine	2009	13	Retrospective	NOP vs OP	153	137	Baseline only	III
5	Bridwell et al.*19*	Spine	2009	30	Prospective	NOP vs OP	75	85	2 years	II
6	Dickson et al.	JBJS	1995	14	Retrospective	NOP vs OP vs Control	30	81	5 years	III
7	Fu et al.	Neurosurg	2010	5	Retrospective	NOP vs OP	105	34	Baseline only	III
8	Fu et al.	Spine	2014	1	Prospective	NOP vs OP	341	156	Baseline only	III
9	Glassman et al.*33*	Spine	2010	15	Prospective	NOP only (Treatment vs No-treatment)	123	0	2 years	II
10	Glassman et al.*36*	Spine	2007	15	Retrospective	NOP vs OP	161	161	Baseline only	III
11	Carreon et al.*61*	Spine	2019	0	Retrospective	NOP vs OP	81	81	5 years	II
12	Kelly et al *2*	JBJS	2019	0	Prospective	NOP vs. OP	144	142	2 years	II
13	Kluba et al.	Arch Orthop Trauma Surg	2009	2	Retrospective	NOP vs OP	29	26	2 years	III
14	Li et al et al.	Spine	2009	16	Retrospective	NOP vs OP	49	34	2 years	III
15	Liu et al.	Ochsner J	2014	8	Retrospective	NOP vs OP	225	239	1 year	III
16	Liu et al.*24*	The Spine J	2016	2	Retrospective	NOP only (rMCID vs mMCID)	215	0	2 years	III
17	Neuman et al.*6*	Spine Deformity	2016	0	Prospective	NOP vs OP vs RAND	115	113	Baseline only	II
18	Parsch et al.	Clin J Sports Med	2002	6	Cross-sectional	NOP vs OP vs Control	28	31	2 years	III
19	Passias et al.*22*	The Spine J	2018	0	Retrospective	NOP vs OP vs CROSS	189	321	2 years	III
20	Pekmezci et al.	Spine	2009	2	Retrospective	NOP vs OP	61	30	Baseline only	III
21	Pugely et al.	Spine	2017	0	Prospective	NOP only (SAE vs non-SAE)	105	0	2 years	II
22	Scheer et al.	J Neurosurg Spine	2015	6	Retrospective	NOP vs OP	186	235	2 years	III
23	Scheer et al.*12*	Spine	2018	3	Retrospective	NOP vs OP	221	258	2 years	III
24	Schwab et al.*5*	Spine	2013	45	Retrospective	NOP vs OP	314	178	Baseline only	III
25	Slobodyanyuk et al.	Neurosurg Focus	2014	3	Retrospective	NOP only (NOP vs Normative data)	189	0	1 year	III
26	Smith et al.	J Neurosurg Spine	2008	6	Retrospective	NOP vs OP	156	51	Baseline only	III
27	Smith et al.	Spine	2009	18	Retrospective	NOP vs OP	112	96	2 years	III
28	Smith et al.*42*	Neurosurg	2009	22	Retrospective	NOP vs OP	170	147	2 years	III
29	Smith et al.	Eur Spine J	2013	6	Retrospective	OP	276	0	2 years	III
30	Smith et al.*43*	Neurosurg	2016	11	Prospective	NOP vs OP	223	246	2 years	III
31	Terran et al.	Neurosurg	2013	21	Retrospective	NOP vs OP	308	219	Baseline only	III
32	Yamada et al.	Spine	2016	0	Prospective	NOP vs PIPI	53	109	2 years	II
33										
34						Total ASD Patients	5117	3497		

Table 1B

	A	K	L	M
1	**Authors**	**Type of NOP Tx Mentioned**	**Comment**	**Scoring**
2	Acaroglu et al.	Not specified		None
3	Acaroglu et al.*21*	Observation, majority NSAID/analgesics, 12/371 PT, 6 injections		**Partial**
4	Bess et al.	Not specified		None
5	Bridwell et al.*19*	observation, medictions, PT, steroid injection, other	(not specified for individual pts)	**None**
6	Dickson et al.	Not specified		None
7	Fu et al.	narcotics, PT, aquatic therapy, pain management referral, steroid injections	(not specified for individual pts)	None
8	Fu et al.	Not specified		None
9	Glassman et al.*33*	medication, PT, exercise, steroid injection, nerve blocks, chiropractic, pain management referral, bracing, bedrest	**compared different nonop treatments**	**Partial**
10	Glassman et al.*36*	Not specified		**None**
11	Carreon et al.*61*	Non-Op care not controlled, just recorded	Study focussed on costs	**None**
12	Kelly et al *2*	PT (standardized and tailored but not protocolized), Injections, Oral Meds, "Complementary resources"	Surgery beneficial to "Unsatisfied" patients	**Partial**
13	Kluba et al.	NSAIDs, opioids, PT, bracing, steroid injection, acupunture	(not specified for individual pts)	None
14	Li et al et al.	Not specified		None
15	Liu et al.	Not specified		None
16	Liu et al.*24*	Not specified		**None**
17	Neuman et al.*6*	medication, PT, steroid injection, nerve block, alternative modalities	**compared different nonop treatments**	**Partial**
18	Parsch et al.	Not specified		None
19	Passias et al.*22*	NSAIDs, PT, steroid injection, bracing	(not specified for individual pts)	**None**
20	Pekmezci et al.	Not specified		None
21	Pugely et al.	Not specified		None
22	Scheer et al.	Not specified		None
23	Scheer et al.*12*	Not specified		**None**
24	Schwab et al.*5*	Not specified		**None**
25	Slobodyanyuk et al.	observation, medictions, PT, exercise, steroid injection, bracing, bed rest	(not specified for individual pts)	None
26	Smith et al.	NSAIDs, opioids, PT, steroid injection, pain management referral	(not specified for individual pts)	None
27	Smith et al.	NSAIDs, PT, steroid injection, opioids	(not specified for individual pts)	None
28	Smith et al.*42*	NSAIDs, PT, steroid injection, opioids	(not specified for individual pts)	**Partial**
29	Smith et al.	N/A		None
30	Smith et al.*43*	medication, PT, steroid injection, bracing	(not specified for individual pts)	**None**
31	Terran et al.	Not specified		None
32	Yamada et al.	NSAIDs, PT, counseling	(not specified for individual pts)	None

Scoring refers to our stated workgroup objective to categorize the level of NOP care according to three prescribed classifications:

1. Non-Care (absent or not defined)
2. Partial Care (Limited use or definition)
3. Adequate (Well defined and utilized)

We conducted a first pass to determine what NOP treatments were specified (if any). Our results were consistent with the Yerameneni group, which reported that 57% of the papers did not specify the type of NOP treatment provided to the patients. Of the remaining papers, 15 of them identified in some way the general type of NOP that was included in their study. We selected 13 of these papers for full review, primarily based upon the number of patients, length of FU, and number of times the article has been cited (Kelly, Schwab, Neuman, Scheer, Bridwell, Acaroglu, Passias, Liu, Glassman 2007, Glassman 2010, Smith 2009, Smith 2016, Carreon)

The overall results of our review are presented in Table 1B. As seen in the Scoring column, there were 26 papers (84%) categorized as NON-CARE, whereby the type of NOP was either not mentioned, or was not specified for individual patients. There were 5 papers (16%) categorized as PARTIAL CARE, which did identify the type of NOP treatment specified for patients in the study but was very limited in defining the level of care required. Finally, there were NO papers (0%) categorized as ADEQUATE, evidencing a well-defined and utilized NOP protocol prior to proceeding to surgery for ASD.

Future Considerations for Research and Clinical Care

For failure of non-operative care to be considered an indication for surgery, the components of that care must be defined and categorized both for ongoing research and clinical decision-making. There are three categories:

1. Non-care – Treatments are not defined, implemented and documented.
2. Adequate non-operative care – effective treatments implemented for all the aspects of a patient's condition. Chronic pain is complex, and all the variables have to be addressed simultaneously to consider a given treatment program adequate. Variables include:
    a. Education
        i. Nature of their structural issues and prognosis with or without treatment
        ii. Understanding the neurological nature of chronic pain
        iii. The effect of environmental/ family stresses on their pain and decision-making.
        iv. The benefits and risks of a given procedure
        v. It is not possible to accomplish this in a single visit and major surgical decisions should not be made on the first visit. The decision-making process should occur over months in the context of the overall prehab process.
    b. Sleep – consistent lack of restful sleep affects pain and the immune system. Sleep apnea has an adverse effect on the cardiopulmonary system. Insomnia has been demonstrated to induce chronic pain.
    c. Stress – well-documented that anxiety, catastrophizing, depression and somatization adversely affect outcomes.
        i. Disability is a major source of stress. Patients trapped and angry.
    d. Physical conditioning
    e. Life outlook – anger has been shown to exacerbate pain
    f. Medication management – opioids and other mood-altering medications need to be defined and stabilized.
3. Non-operative care partially addressed
    a. Treatment approaches that are defined and partially accomplish the above.

Indications for Adult Deformity Surgery vs Risks

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Defining Adult Spinal Deformity

Adult spinal deformity may occur as the result of a number of conditions and patients may present with a heterogeneous group of symptoms. Clinical presentations vary and may be related to progressive balanced or unbalanced deformity, loss of function, axial pain, radicular pain, and/or neurologic symptoms. However, symptoms are associated with progressive and asymmetric degeneration of the discs, facet joints, and other spinal elements potentially leading to neural element compression. Patients with radiographic evidence of scoliosis greater than 30 degrees, thoracic hyper-kyphosis greater than 70 degrees, or lumbar hypo-lordosis less than 20 degrees (flat back) were considered to have ASD.

The main purpose of surgical treatment in ASD is to relieve pain and neurological signs for affected patients; the end point is a stable, balanced spine with increased patient function. In the past, the risk/benefit ratio has trended toward

non operative conservative treatment for most surgeons, however; recent advances in surgical technique, instrumentation, neurologic monitoring, as well as improved diagnostic imaging, perioperative anesthesia, and intensive care have led toward increasing utilization of surgical treatment for patients with adult deformity. In this evolutionary phase of ASD surgery, surgical indications have not been clearly defined.

Non-Operative Care

1. As compared to pediatric deformity, surgical indications for adult deformity are more likely to be informed by pain and disability as opposed to structural features such as severity of deformity/curve magnitude (Bess 2009).
2. Only 10% of spine surgeons are addressing the known risk factors for a poor outcome prior to proceeding with surgery (Young).
    a. Patients who do fail the surgical option tend to have higher baseline SRS-22 scores, depression, comorbidities, baseline deformity, and prevalence of prior surgery (Smith, Scheer).
3. There are no well-defined parameters describing reproducible rehabilitation protocols for this population. General recommendations are given for muscle strengthening and aerobic conditioning (Kelly 2019).
4. Despite study showing operative management of individuals with adult spinal deformity is more effective than non-operative management (Smith–ISSG), except in patients with significant baseline disability (Acaroglue), there are methodological flaws such as nonoperative treatment being essentially being random care.
5. There is almost no evidence on conservative management (physiotherapy, bracing, etc.) in adult deformity, but bracing and thoracic extension exercises have been found to improve balance score, spinal deformity and pain in patients over 60 with hyper kyphosis (Bettany-Saltikov J, Bansal, Katzman W).
6. The largest body of evidence in conservative management of adult deformity is from populations with hyper-kyphosis, for which bracing and physical rehabilitation have shown some benefit (Katzman a,b).
7. Indications for conservative treatment of degenerative scoliosis include physical conditioning and exercise, pharmacological agents for pain control, and use of orthotics. It is generally accepted that conservative management strategies should be employed prior to surgery, however specific protocols are not well studied (Kotwal).
8. Although bracing is considered a reasonable conservative management modality, the optimum angle to brace in adult deformity is unknown (Glassman).
9. Pain that persists after 12 months is a disease of the brain and structural interventions for pain are not effective (Hashmi, Mansour).
10. Randomized studies using sham controls have shown that interventions for chronic knee and spine pain are consistently ineffective (Jonas).

Operative Intervention

When examining the indications for surgical intervention in ASD, it is best to categorize patients according to their presenting symptomatology. It has been suggested that patients can be broken into the following groups (Ploumis).

1. Decompensated Deformity
2. Progressive Deformity
3. Curve magnitude
4. Neurological Compromise
    a. Spinal Cord
    b. Nerve Roots
5. Axial Pain

Decompensated Deformity

Sagittal

a. It has been shown that in patients who are pitching forward due to spinal problems, a condition called positive sagittal balance, that there can be severe disability and pain associated. In fact, a direct correlation has been shown between the amount of positive sagittal balance (using a metric called the sagittal vertical axis of the C7 vertebral body centrum) that exists and patients' quality of life (Glassman 2005).
b. Positive sagittal balance is felt to be caused by loss of the normal swayback of the lumbar spine called lumbar lordotic curvature (Lumbar Lordosis) and a failure of the body's normal compensatory mechanisms, principally the rotation of the pelvis (as measured by the Pelvic Tilt).
c. Based on multivariate analysis of multiple radiographic parameters measured in the spines of ASD patients, these sagittal plane parameters appear to be the most strongly correlated and explanatory for pain and disability (Schwab).
d. More recently, a new x-ray parameter, called the T1 pelvic angle has been used to assess the combined effect of a loss of lordosis on posture and pelvic rotation in the context of ASD surgery, and shown to be strongly correlated to outcomes as well (Ryan). The deviation from the normal values of these x-ray parameters are not in and of themselves an indication to proceed with surgery but rather allow the surgeon to quantify the deformity and contextualize it in the setting of the patient's symptoms.
e. Glassman et al (2010) reported that sagittal balance, rather than coronal balance and curve magnitude, is the radiographic feature that correlates most with disability and worse HRQL scores. Ploumis et al found in severe deformity cases, balance was the most important factor indecision making.

Coronal

a. Effect on Surgical Outcome
    i. Correction of frontal imbalance had no effect on the surgical outcome, according to Daubs et al. (Daubs), although the change in lumbar Cobb angle did have a limited impact. Preoperative C7 coronal alignment did not affect surgical outcome in a retrospective cohort of 227 ASD patients (Smith 2015), nor in a retrospective cohort of 557 patients (Scheer). Cho et al. (Cho) observed on a cohort of 45 patients that preoperative C7 coronal plumb line had no effect on postop sagittal balance, while preop sagittal C7 plumb line did ($p = 0.002$).
b. How much of decompensation has been documented to be an absolute indication for surgery?
    i. The European Spine Study Group performed a prospective study on 989 patients, aiming to elucidate the factors for decision making process in treatment of ASD (Fujishiro). Coronal compensation (C7 plumb line) did not lead to surgery; nonsurgical young subjects (N = 414) had a decompensation of 16 ± 13 mm while older (N = 575) had 20 ± 17 mm.
c. How much coronal decompensation is tolerated by patients?
    i. With considerations on sagittal balance, Schwab et al (Schwab), concluded that the question of "How much can you tolerate?" cannot meet with definitive answers but requires ambition to be balanced with good clinical judgment.". The same principle can likely apply to coronal balance, although the literature is sparser.

Progressive Deformity

In the literature review by Bradford et al, it is reported that curve progression with coronal (or sagittal) imbalance should be an indication for surgery (Bradford), but without specific references to support this.

Curve Magnitude

There are patients with adult spinal deformity whose scoliosis developed as an adolescent (termed idiopathic scoliosis) and became problematic later in life as normal spinal degeneration occurred. In other patients, the scoliosis develops later in life as the result of asymmetric collapse of the intervertebral discs or lateral slippage of the vertebral bodies.

The pathophysiology of these two types of scoliosis is distinct, and though often lumped together uniformly, should be treated and managed distinctly. Many patients are able to maintain global balance of their spine despite the presence of scoliosis, resulting in preserved ability to keep the spine aligned over the pelvis. There has been weak correlation between the magnitude of the scoliotic curvature itself and quality of life measures (Schwab). Patients with maintained postural alignment in the coronal plane can potentially have large Cobb angles but remain clinically asymptomatic. This is especially true for patients with idiopathic scoliosis of adulthood.

In the absence of specific protocols in the literature for adults with spinal deformity, some information may be gained from studies that have demonstrated successful improvement in deformity in adolescent scoliotic conditions. In adolescent idiopathic scoliosis, exercise programs that incorporate supervised 3-dimensional trunk strengthening exercises and breathing exercises were shown to improve spinal curvature and reduce postural defects (Otman). However, exercise programs with strict protocols have not yet been extensively studied in adults.

Neurological Compromise – Radicular Pain/Myelopathy

a. ASD patients may be accompanied by compromise of their neurological function. That is, their spinal disease has concomitantly resulted in compression of the 1) spinal cord or 2) individual spinal nerves. The manifestations of neural compromise include limb weakness, numbness, and/or pain, loss of coordination, and inability to control bowel or bladder function. While it is up to the surgeon to determine the level of concern over the specific symptoms present, neurological compromise in the context of spinal deformity may appropriately influence the surgeon and patient toward operative intervention. Typically, the goal is to give the best opportunity possible for recovery of the lost function and to prevent further deterioration that may occur with prolonged non-operative treatment. In many cases, although the priority for surgical intervention may be recovery of neurologic function, the coexisting deformity must be corrected surgically as part of the solution, in order to provide durable success and protection of the neural elements, as well as to protect the patient from short-term failures or recurrence of symptoms. Most providers believe patients in these two groups above have high probabilities of benefitting from surgery (Ploumis).
b. Glassman, et al. found that patients with components with radicular leg pain were more likely to proceed with surgical treatment whereas patients with back pain did not show a difference between surgical or nonsurgical treatment. Ploumis felt that in deformity cases with neurologic manifestations, neurology was the most important factor.

Axial Pain

Many patients do not meet the structural criteria for surgical intervention. These are patients who fall into the radiographic definitions for ASD and have severe, progressive axial or mechanical pain that is refractory to non-surgical therapies. In these cases, the decision to perform surgical intervention can be difficult. The surgeon must determine whether they believe that the patient's back pain will improve meaningfully with correction of the spinal deformity (Smith 2008). Additionally, the patient must determine whether they are disabled significantly enough by their pain that attempts at surgical treatment are worthwhile, when considering the risks involved. In general, patients who have minimal or modest amounts of pain, are able to perform most of their daily activities unencumbered and have not demonstrated significant progression on serial imaging are not considered ideal surgical candidates. Most surgical providers would recommend continued non-operative management in these patients with serial imaging and close clinical monitoring. Health-related quality of life or patient-reported outcome measures can be helpful in quantitatively assessing the severity of preoperative impairment, and thus they provide additional guidance on surgical candidacy (Richner-Wunderlin).

Axial pain alone in a balanced spine cannot currently be considered an indication for ASD surgery. The main problem is that a thoughtful organized approach to non-operative care utilizing well-established effective treatments has not been defined and documented in the surgical literature.

Risks/Complications

Adult patients have an increased risk of experiencing surgical complications than adolescents. Major complications include pseudarthrosis (5 to 27%), residual pain (5 to 15%), neurologic injury (1 to 5%), infection (0.5 to 5%), and thromboembolism (1 to 20%)

The main purpose of surgical treatment in ASD is to relieve pain and neurological signs for affected patients; the end point is a stable, balanced spine with increased patient function. In the past, the risk/benefit ratio has trended toward nonoperative conservative treatment for most surgeons, however; recent advances in surgical technique, instrumentation, neurologic monitoring, as well as improved diagnostic imaging, perioperative anesthesia, and intensive care have led toward increasing utilization of surgical treatment for patients with adult deformity.

What is the ballpark complication rate for adult deformity surgery? (Major, Minor, Catastrophic)

Number of levels fused did not affect the number of complications in a cohort of 557 ASD surgeries (Scheer), nor functional outcome in a cohort of 43 degenerative scoliosis patients (Farrokhi), in 92 de novo scoliosis (Simon). Fused levels > 5 did not increase infection rate in a retrospective cohort of 830 patients (Pull ter Gunne). In a cohort of 306 patients (age range 50-83), having more than 4 instrumented levels was associated with increased number of complications.

Complication Rates in ASD				
No. Patients	Levels Fused	Complication Rate	Comments	Reference
557	11 ± 4	27% major intraoperative or perioperative complications	Of these 27%: 39% operative, 23% cardiopulmonary, 16% infection	(Scheer et al. 2017)
227	10 ± 4	53% minor complications 40% major complications	Results at 2 years	(Smith et al. 2015)
43	4.4	14% adjacent segment disease 12% mild coronal and sagittal imbalance 2% PJK	Results at 2 years	(Farrokhi et al. 2017)

92	5 ± 2	25% early complications 53% late complications (> 30 days)	Adult de novo scoliosis.	(Simon et al. 2018)
101	9.4 ± 4	56 % medical complications 15% surgical complications	Patients > 70 years old. Only 50% of the patients were ASD	(Ibrahim et al. 2019)
306	7	39% (14% general complications, 5% infectious, 8% neurologic, 24% mechanical complications)	Risk factors: instrumented levels, fusion to the sacrum, pedicle subtraction osteotomy.	(Charosky et al. 2012)
21	10.5 (range 5-15)	62% perioperative complications 38% major complications (no deaths) Long term complication rate: 52%	Patients > 75 years old. Age did not increase major complications	(Acosta et al. 2011)

Education

Howard Schubiner, MD; Allan Abbass, MD; DR Clawson, MD

The Psychophysiological Basis of Chronic Pain

Written by Howard Schubiner, MD and Allan Abbass, MD

The psychophysiological basis we propose for the treatment of chronic pain is based upon the following principles as described by Lumley and Schubiner (Psychosomatic Medicine, 2019) and elaborated in Abbass and Schubiner, (2018):

1. Current approaches, such as cognitive-behavioral therapy, ACT and mindfulness-based approaches have limited efficacy with average pain reduction of 0.5 points on a 10-point pain scale and effects sizes in the range of d=0.3.
2. Chronic pain is heterogeneous and the treatment for nociceptive pain should differ from that of central or neuroplastic pain.
3. There is a weak correlation between imaging findings and pain, therefore it is important to avoid automatically attributing pain to imaging results.
4. The brain not only modulates, but also generates pain, and we propose a careful diagnostic assessment to rule in neuroplastic pain.
5. Adverse life experiences and psychological conflicts are important in understanding the origins and treating chronic neuroplastic pain.

6. Emotional expression and processing are important components of chronic pain treatment.
7. Neuroplastic pain can be substantially reduced or eliminated with proper psychological interventions.

Diagnosing Centralized Pain

The suggested approach begins with a detailed assessment to distinguish, as much as possible, central/neuroplastic pain from nociceptive pain. If one avoids over-reliance on imaging findings, it is possible to rule in central pain by findings of pain that 1) shifts in location, 2) turns on and off in random fashion or while distracted or in an enjoyable setting, 3) is in a distribution pattern that is non-physiological (e.g., large areas, symmetric patterns) and cannot be explained by imaging findings, 4) is triggered by innocuous stimuli such as heat, cold, weather changes, light touch, smells, sounds, or light, 5) is triggered by occurrence or anticipation of stressful events, 6) can be elicited by imagining a pain-provoking stimulus or 7) elicited by focusing on emotion-laden situations in the office assessment.

Other data points that can point to a central pain syndrome are 1) high levels of pain catastrophizing, 2) life time occurrence of other central pain syndromes, such as irritable bowel syndrome, headaches, pelvic pain, chronic regional pain syndrome, fibromyalgia, tinnitus, dizziness, 3) mental health conditions such as anxiety and depression, 4) history of adverse childhood events, and 5) personality traits of internalizing, including low self-esteem, perfectionism, overly sensitive, and submissive. When a clinician carefully synthesizes all of the above information, most patients will fall into a category of nociceptive or central pain syndrome, although some will be diagnosed as having a combination of the two.

Treating Chronic Neuroplastic Pain

Education

Once a diagnosis of neuroplastic pain has been made, the initial step should be clear and definite pain education. It is critical to allay fears on the part of the patient that their pain is “all in their head.” All pain is generated by the alarm mechanism (known as the salience network) of the brain, whether due to physical injury or not; and therefore, all pain is real. To imply that pain is not real suggests blame or weakness on the part of the patient; and these implications should be forcefully rejected. Connection to the patient and compassion for the patient must be cultivated and demonstrated in order to successfully treat chronic central pain. Explanation of the concept of predictive coding (Feldman–Barrett) can proceed in order to help the patient understand their condition. The data obtained in the assessment should be personalized so that the patient can see that their condition clearly fits into this theory.

Cultivating Feeling Safe

The next steps are to encourage the patient to reduce perceived danger of the pain and increase their adaptive behaviors. This is accomplished by exercises to allay fears and reduce focus on the pain. The following are techniques that have been shown to be effective (references): 1) frequent affirmations of health and safety to calm the alarm mechanism in the brain; 2) mindful awareness of painful sensations in order to reduce reactivity to them; 3) reducing reactivity to stimuli that provoke pain by training the brain to be calm with graded exposure to those stimuli; 4) gradually re-engage in activities that have been excluded from their lives, such as social engagements and physical activities; 5) cultivate opportunities for joy and pleasure, as well as meaning and purpose; 6) make changes that balance connecting to others and assertive communication to create healthy relationships at home and at work.

Processing Past Trauma

Finally, it can be critical to help patients process traumatic situations that occurred in their past and/or that are current. There are several methods for accomplishing this. For example, emotional disclosure can occur by writing exercises designed to promote expression of emotions (see Pennebaker). These are easily accessible for clinicians to prescribe and acceptable to most patients. However, their efficacy in controlled trials is somewhat limited (Lumley). Powerful therapeutic techniques have been developed to fill this void and many patients with chronic pain can benefit from them. Intensive short-term dynamic psychotherapy (ISTDP) is a treatment that has been well-studied and has been shown to have robust effects in somatic symptoms (Abbass, 2015, Reaching through Resistance). It involves facilitating the expression of emotions in real time through graded exposures that allow the patient to reduce resistance to feelings that are often suppressed. It is a way of processing traumatic life experiences by facilitating expression of anger, exploration of guilt, allowing grief to be expressed, and encouraging self-compassion and caring to create healing. There are many other methods of accomplishing emotional processing that are in wide use (such as Internal Family Systems, Eye movement desensitization and reprocessing, emotionally focused therapy, and Somatic Experiencing), but are supported by limited empirical evidence to date.

The Role of the Autonomic Nervous System in the Context of Spinal Deformity

DR Clawson, MD

As we re-contemplate deformity and specifically scoliosis and their relationship to pain it seems important to contemplate what else we may have missed in building our models for deformity and scoliosis. The work of Stephen Porges has pointed out the relationship between our autonomic nervous system and our cranial nerves, facial expressions, vocalizations and auditory input.

There are significant physiologic changes that occur within us associated with where we are on the spectrum of threat/stress to safe/relax. It is important to recognize our entire physiology, body and mind, is altered based on whether we are in threat/stress or safe/relax physiology, and next to our facial expressions our spine and posture is the part of our bodies most influenced by our sense of safety or danger and our emotions. The model for consideration suggests that in fight we are flush with dopamine and norepinephrine. Our posture is upright and confident to aggressive. If we sense we are losing a battle our dopamine will start to fall and we will shift into flight physiology. Our norepinephrine continues to flow and we assume a more protective posture with head and neck slightly forward and a rise in our shoulders mediated through cranial nerve IX, the accessory nerve. If things deteriorate further we can shift into freeze physiology, the physiology of surrender. Both dopamine and norepinephrine run low and we become immobile and slumped into a significant kyphosis communicating defeat and submissiveness. This can progress into faint physiology, the physiology of extreme energy conservation and feigning death with the hope of surviving an attack. We are no longer upright and become prostrate or fetal in our posture. Serotonin is low in all of these states - fight, flight, freeze, faint.

Serotonin is a prosocial transmitter associated with a more neutral, less aggressive or less submissive, posture. Higher serotonin is characterized by being fully upright, but with more lordosis and openness. It is a posture that invites approach, connection and bonding. We know scoliosis is associated with low serotonin levels. This invites a

chicken and egg question. Do patients with scoliosis have image or self-esteem issues that result in low serotonin or does the physiology associated with low serotonin have a causative factor in the initiation and development of scoliosis? It is likely the latter. Consider adolescent scoliosis in this model. This can be a tumultuous developmental stage characterized by separation from parents and awkward relationships with peers. Adolescents can suffer from a loss of touch and a sense of physical disconnection and emotional disconnection. They can feel very ungrounded. It is also a time of extreme sensitivity and emotional, social and spiritual pain can run high. It is a time where both mental health and postural disorders tend to rise.

With this information, it behooves us to move beyond structure in understanding our patients. It is important to consider the complexity of the human species and how our sense of being safe, fully seen and secure influences both our minds and our bodies. The threat/stress response plays a significant role in illness and disease. We need to focus not on pain scales but threat/stress scales to truly see our patients fully and treat them appropriately. Most importantly, we must do no harm.

Structure always needs to be explored and ruled out first especially when there is a suggestion of infectious, oncologic or neurologic pathophysiology, but we cannot stop there. Who knows we may discover that some deformity and in particular scoliosis if treated early and properly requires no structural intervention at all.

The study and proper treatment of the acute and chronic threat/stress response is the challenge of our time as the toxicity of a chronic threat/stress response may be responsible for the majority of illness, disease and medical costs we see today. Deformity and scoliosis may fall into a subcategory of chronic threat/stress. Certainly, chronic neck and back pain belong in this category.

Sleep – The Foundation of Non-Operative Spine Care

David Hanscom, MD and Lina Fine, MD

Addressing sleep is the first step and an absolute necessity in solving either chronic mental pain or physical pain; both of which create anxiety. Lack of sleep not only increases the perception of pain; it decreases coping skills. It is challenging to effectively implement a rehab program in the presence of disordered sleep.

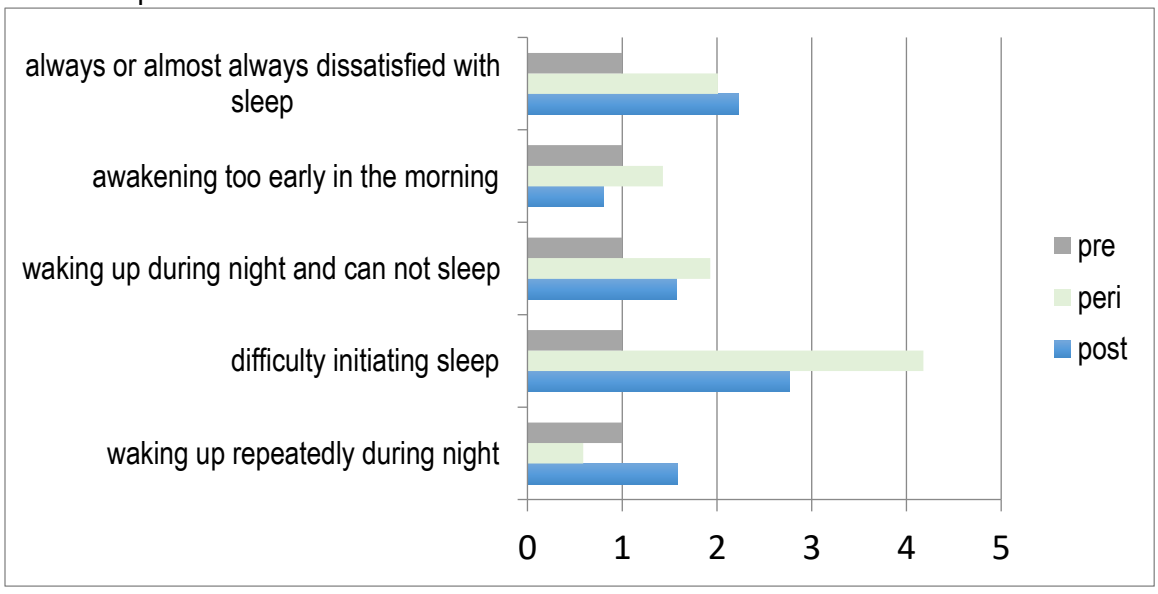
A recent study demonstrated that there is a higher correlation between disability and lack of sleep than there is between disability and pain (Zarrabian). Pain distorts one's ability to fall and stay asleep while poor and truncated sleep perpetuates pain symptoms. Nociceptive pathways and sleep–wake pathways may share common central serotonergic transmission. A survey of 18,980 individuals from five European countries showed that significantly more participants with chronic painful conditions (e.g., limb or joint pain, backache, gastrointestinal pain or headache) than those without pain experienced insomnia. Compared to individuals without chronic pain conditions, those with pain were three times more likely to report difficulties with initiating sleep, maintaining sleep, early morning awakenings and nonrestorative sleep (Ohayon).

A large population-sampling study from Turkey demonstrated that patients in chronic pain had almost double the problems with insomnia compared to those without pain (Karaman). Insomnia also seemed to be associated with a higher intensity of pain.

The Turkish study did not look at whether lack of sleep caused the chronic pain, or the pain interfered with sleep, but other research has been shown that insomnia does induce chronic pain (Agmon, 2014). Sleep is critical for processing, storing and clearing out of the information fed into your brain during the day and lack of it is disruptive to this process. This study followed more than 2,000 patients for almost four years. They discovered that there was almost a 40 percent higher chance of suffering from chronic back pain in the presence of insomnia but didn't find the reverse causation to be problematic.

There may be confounding factors that lead to poor sleep such as underlying mental illness and onset of menopause. These confounding factors are often important players that need to be considered when addressing sleep difficulties in patients with pain. For example, menopause is an important physiological change in women that has physiological and psychological implications. As the chart below demonstrates, sleep difficulties arise during this period that may layer on the nocturnal symptoms associated with pain.

Figure 1. Odds Ratio for Self-Reported Sleep Problems among Women (n=589) Pre, Peri and Postmenopausal



Basic Sleep Requirements

An average adult requires 7 to 8 hours sleep with fewer than 6 and more than 9 hours correlating with health adverse outcomes. Thirty percent of working population in the United States sleeps for fewer than six hours a day. Sleep deprivation may lead to decrease in glucose metabolism by a third (Spiegel), elevation in C-reactive protein and IL6 (Patel). Of note, sleep for longer than 9 hours appears to have similar effects. Onen and colleagues have shown that

men showed hyperalgesia to mechanical stimuli following forty hour total sleep deprivation and robust analgesic effect after selective slow wave sleep recovery (Onen).

Approach to Assessing Insomnia

Insomnia is only a symptom with many possible causes and should be considered as part of a broader clinical presentation. There are over one hundred sleep disorders. The two most common are sleep apnea and restless leg syndrome. The mental health/ pain issues must always be taken into consideration in the context of the decision to perform spine surgery. It is reasonable to first screen for these two sleep disorders in addition to assessing mood and stress.

Sleep Apnea

The first important step in such assessment would be to evaluate patient for sleep-disordered breathing. Snoring, awakenings with gasping, palpitations, panic, dry mouth/sore throat are common symptoms of sleep apnea syndrome. However, there are often more subtle symptoms of morning headache, anxiety, poor daytime concentration that would hint at potential sleep disordered breathing, especially in women.

	Men	Women
Snoring/Apneas	***	*
Sleepiness	***	**
AM Headaches	*	***
Depressive Features	*	**
Apnea Freq.	**	*
Hypopnea Freq.	*	**

(adapted from (Kapsimalis & Kryger, 2002))

Using a quick screening tool such as STOP BANG questionnaire would be a helpful way to screen many patients, but these more subtle symptoms that demonstrate poor daytime functioning should be considered as well.

Snoring (yes/no)

Tired (yes/no)

Observed apneas (yes/no)

Pressure, treatment for blood pressure (yes/no)

BMI >35 (yes/no)
Age >50 (yes/no)

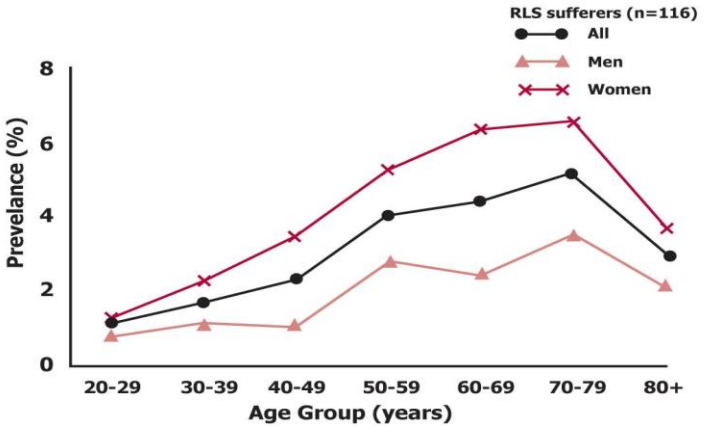
Neck circumference >40 cm (yes/no)

Gender male (yes/no).

Answering “yes” to more than 3 questions above is suggestive of high risk of sleep apnea (Chung). Patients at risk can then be assessed with a polysomnogram in a sleep laboratory setting or with a home sleep test device that is especially helpful in more severe cases of sleep apnea.

Restless Leg Syndrome

The next important step in the patient who struggles with sleep is an assessment for abnormal leg movements of sleep and restless legs syndrome (RLS).



(Allen et al., 2005)

Patient may report a sensation of “creepy-crawly”, “worms moving”, “soda bubbling in the veins”, “grabbing sensation”, “shock-like feelings”. RLS results in disturbed sleep, sleep onset insomnia and is associated with higher risk of depression, anxiety and somatic pain(Allen et al., 2003).

Diagnostic Criteria for RLS Include:

1. Urge to move: irresistible, involves both legs but may involve arms and trunk
2. Worsening AT REST (body position should not matter)
3. Relief with movement (no symptoms during movement)
4. Worsening in the evening or at night (circadian fluctuation)

Restless legs syndrome may mimic positional discomfort, cramps, positional ischemia, neuropathy, radiculopathy, hypnic jerks and should be careful distinguished from these conditions (Hening). RLS is four times more likely in first-degree relatives. Usually, polysomnogram is not needed unless the patient cannot articulate symptoms.

Restless legs syndrome is a condition that the patient is able report to the provider while periodic limb movements of sleep is a condition diagnosed in the sleep laboratory with recorded periodic episodes of repetitive and highly stereotyped limb movements that occur during sleep and lead to impairment in sleep quality or daytime functioning. Periodic limb movements disorder is defined by presence of periodic limb movements electrographic arousals on a sleep study that result in broken sleep and daytime symptoms of fatigue.

Insomnia

Insomnia encompasses the inability to initiate sleep, maintain sleep or reach a state of restfulness and refreshment upon awakening. It may be associated with daytime symptoms of fatigue, memory deficits, social/vocational/academic performance deficits, mood changes, daytime sleepiness, lack of motivation, vulnerability to accidents, somatic symptoms and preoccupation with sleep that perpetuates the cycle of insomnia.

The final step, regardless of the presence of sleep apnea or restless syndrome is to assess the underlying mental, physical and environmental factors that affect sleep, and which comprise a delicate balance for patients with pain. These individuals may suffer from excess central autonomic activity triggered by pain as well as peripheral autonomic hyperactivity, including tachycardia, hypertension, mydriasis, vasoconstriction in extremities and hyperreflexia. Such state of hyperarousal would interfere with normal relaxation that precedes sleep (Latremoliere). Several factors may contribute to this heightened state.

1. Environmental
    a. Personal losses
    b. Change in living situation
    c. Threats – home or work
2. Disability/ litigation
    a. Being trapped in the medical-legal system is a stress that affects every aspect of a person's life.
    b. Litigation is an ongoing stressor that can last for years
3. Mood disorders
    a. Anxiety
    b. Anger
    c. Depression
    d. Fear avoidance
    e. Catastrophizing

Although this list sounds daunting, all of them can be quickly evaluated with the use of well-designed intake questionnaires.

Treatment Approach

Often, due to difficulty of assessing the cause and effect between insomnia and mood, it is helpful to manage these conditions in conjunction with medication and non-medication approaches.

There are several levels of engagement:

1. Directed by the patient
2. Patient-directed with help from primary care
3. Evaluation and treatment in conjunction with a sleep specialist.

Recommendations for addressing and treating insomnia as part a structured rehab process:

1. Sleep is a critical component of treating pain and must be addressed in every patient as part of a non-operative treatment program.
2. The two major sleep disorders, sleep-disordered breathing and restless leg syndrome must be ruled in or out and other disordered sleep diagnoses considered.
3. Insomnia is an additional symptom and must be treated regardless of the cause. Identifying the reasons will help guide the treatment plan.
    a. Addressing and treating the stressors around chronic pain will be address in the "Stress" section of the non-operative manual.

Patients should be sleeping at least six, not necessarily consecutive, hours in a 24-hour period for six weeks prior to deciding on a major spinal surgery. It should be a restful sleep that does not result in daytime sleepiness.

Physical Factors

Sabrinia Donzelli, MD; Paul Anderson, MD; Jesse G. Eisler, MD, PhD; Ann M. Hayes, PT, DPT, MHS, OCS*; Jim Robinson, MD*

Physical Rehabilitation in Non-Operative Management of Adult Spinal Deformity

Treatment of Adult Spinal Deformity is complex, and outcomes are influenced by multiple factors, including but not limited to severity, progression, psychosocial status (Amaral), and comorbidities. One of the first lines of treatment in the management of ASD is physical rehabilitation, along with other non-operative management strategies such as pain medication and injections. In many cases, this is considered the first line of treatment before more invasive options such as surgery are considered. However, many practitioners and patients question whether this is necessary for all cases, and what the expectations should be for symptom improvement with non-operative management. Recent studies have investigated whether non-operative management for patients with spinal deformity is as effective as operative management. Some studies have shown that operative management is more effective than non-operative management, particularly in the first 1-2 years after surgery (Smith, Acaroglu). Other studies have demonstrated that in the longer term (>5 years), there is no difference, and the cost is higher for operative management relative to the quality of life improvements and the potential risk of complications and re-operation (Carreon, Kelly).

Because of these findings, physical rehabilitation has continued to be considered an important and valuable option for treatment. An example of this is adult scoliosis, which is typically divided into two types—adult scoliosis of adolescent onset and degenerative or denovo scoliosis (Bettany-Saltikov, 2014,2017). While these categories tend to be grouped together with regards to treatment, the fact of the matter is that a variety of structural features such as stenosis, disc herniation, kyphosis, spondylolisthesis, lateral listhesis, coronal imbalance and lateral shift could be contributing to the resultant pain and disability being experienced by the patient. While imaging can detect these pathologies, there are no tests/measures that can determine if they are specific pain producers; without this correlation, it is extremely difficult to determine best practice for intervention .

Current literature-based recommendations for physical rehabilitation are broad and often lack detail for specific protocols. For example, methods of rehabilitation in adults with spinal deformity include aerobic conditioning and exercise, muscle strengthening, and activity modification, but no detailed descriptions of dose and frequency are indicated (Kelly, Kotwal). This makes it very difficult to determine exactly which components of rehabilitation are the most beneficial to include in non-operative management, more or less, the specifics of their dosing.

Current rehabilitation clinical practice guidelines utilize treatment-based classifications that identify probability of successful outcomes in patients with low back pain based on specific physical exam findings and typically based on movement dysfunction (Alrwaily, Delitto). As discussed previously, more granular diagnostic subcategorizations, such as those apparent on imaging, have not been considered in these treatment-based classification algorithms, however, treatment based on directional specificity can be beneficial for obvious reasons—movement that contributes to pain is avoided and movement that elicits pain relief is encouraged. In addition, when using treatment-based classifications with ASD, imaging studies are not necessarily required, resulting in improved cost-effectiveness.

For patients with kyphosis, bracing in addition to physical rehabilitation has been shown to improve balance, spinal deformity, and pain (Bettany-Saltikov 2014, Bansal, Katzman 2007, 2010, Weiss). However, studies have not determined whether there is an optimal angle of deformity for which bracing should be initiated (Glassman 2006).

In the absence of specific protocols in the literature for adults with spinal deformity, some information may be gained from studies that have demonstrated successful improvement in deformity in adolescent scoliotic conditions. In Adolescent Idiopathic Scoliosis, exercise programs that incorporate supervised 3-dimensional trunk strengthening exercises and breathing exercises were shown to improve spinal curvature and reduce postural defects (Otman). During the past 5-10 years, there has been increased evidence to support the use of physiotherapeutic scoliosis specific exercise for AIS as evidenced by randomized clinical trials and systematic reviews. While some of this literature still questions the use of PSSE for AIS (Everett, Day), there's more evidence to support its use, allowing a greater acceptance within the medical community (Fusco, Romano, Schreiber 2015, 2016, 2017, 2019, Park, Burger, Negrini 2019). It is important to mention that when PSSE was first studied, few embraced its results, but with its greater use and over time, its effectiveness has become more apparent (Bettany-Saltikov, 2014). This is important to consider when determining the usefulness of PSSE in the case of ASD. In a 2019 article by Steinmentz, he states that PSSE has been understudied in ASD and encourages further clinical research to determine if it can be as successful in this cohort as it has been in AIS.

While most of the evidence supporting the use of PSSE with ASD consists mainly of case reports or case report series (Negrini 2008, Berdishevsky, Yang). Negrini in 2015 completed a retrospective study of 34 patients with adult idiopathic scoliosis (ADIS) who underwent SEAS exercises, which are scoliosis-specific exercises that attempt to improve postural control and vertebral stability through active self-correction. Neuromuscular postural re-education and ergonomic education are key components of SEAS, which was found to be better than the natural history associated with ADIS. Not only are cohort studies such as these important for supporting the use of scoliosis-specific exercise, but they indirectly support the use of motor and cognitive rehabilitation that has been shown to decrease pain and improve quality of life in those with ADIS (Monticone). There are other interventions that have been

described in the literature that, while a low level of evidence, have reported improvements in pain, chest expansion, and Cobb angle through the application of chiropractic manipulation, exercise, Pilates, or a combination of those interventions (Brooks, Blum, Morningstar). Instead of dismissing these results, we need to determine what these interventions have in common with those that are now being accepted as reasonable conservative interventions for ASD. Obviously, more research is needed in this area and should be a priority, given the number of adults with scoliosis who are being evaluated for surgery in spine clinics. In the meantime, we should be at least be familiar with the above studies and utilize their successful interventions during our non-operative spinal care.

The other significant spinal deformity commonly seen in older adults is hyperkyphosis, which can contribute to pain, low bone mass and vertebral compression fractures, worsening mobility and a decline in physical performance (Katzman 2010, 2011). While further randomized clinical trials consisting of sagittally-directed specific exercise programs would be beneficial, there is already evidence to support its use with these individuals. Exercises or activities that encourage flexion of the thoracic spine should be avoided while active prone trunk lifts (or a variation of them) have been reported to increase spinal flexibility and back extensor strength while decreasing hyperkyphosis, thereby encouraging a more upright standing posture, improved balance, and a decrease in pain (Bettany-Saltikov 2017, Katzman 2007, 2010, Weiss H). In the SHEAF study, Katzman and colleagues described a group of multi-modal spine strengthening and postural exercises that reduced kyphosis in an experimental group of adults with hyperkyphosis when compared to a control group who only received educational health information (Katzman 2017). In the most recent systematic review of exercise interventions that spanned a variety of age groups from adolescents all the way up to older individuals who exhibited postural malalignments in the head, neck, and trunk, it is not surprising that they felt that they could not come to a conclusion on the efficacy of exercise interventions due to the insufficiency of the included studies. However, they did state that the majority of the studies that they examined described some type of positive effect associated with the exercise (Bayattork). A study by Roghani and colleagues in 2019 found that static back extensor force and endurance were significantly lower in individuals with hyperkyphosis than in individuals who did not exhibit it, further supporting the use of back strengthening exercises for individuals with hyperkyphosis.

The lack of studies with individuals with ASD, implementing specific exercises with well described dosing and frequency, is a large gap in the current body of literature, and if more clearly defined, might improve the ability to understand which patients may be more appropriate for non-operative versus operative care. Additionally, many surgeons consider “failure” of non-operative management as an indicator for surgery, making standardization and optimization of conservative management a high priority for future research and better patient care.

Smoking

Despite there are some controversial results it is recognized that smoke habits play a role within the multiple factors involved in low back pain etiology and that smoke could be a risk factor for complication in spine surgery. This is mainly related to the effect of smoke on disc degeneration as well as to the major effects generated by smoke on the vascular system. Evidences from the literature suggest encouraging smokers who are planning major spine surgery to quit smoking before and after surgery to avoid post-surgery complications like blood loss, infections and pseudarthrosis (non-unions).

Smoking and Spine Pathology

Smoking has several well-documented negative effects on health. An association between smoke habits and low back pain has been reported in various epidemiological studies, but the scientific literature reports inconsistent results, and comparisons could be very hard. A systematic review found an association between smoking and low back pain in 51% of the included studies, this association resulted stronger for studies with larger samples (Leboef-Yde). Thus, confirming that smoke is playing a minor role compared to other factors involved and only larger samples are needed to let it to emerge.

Dose response is another issue related to the effect of smoking habits, five cross-sectional studies showed a dose response between smoke and low back pain (Leboef-Yde).

Regarding spine deformities affecting the adult population the role of smoke was never explored as a risk factor for progression or pain–associated symptoms. Scott and colleagues explored the association of smoke and back pain in a sample including also adult patients affected by adolescent idiopathic scoliosis (AIS). For current smokers the OR for back pain intensity was 1.86 (CI95% 1.43-2.42) higher in women and 1.33 (CI 95% 0.95-1.88) higher than for the general population. For former smokers the most estimates of the risks were similar to the expected under the null hypothesis. For the frequency and duration of the low back pain women with AIS had 1.28 higher OR (CI95% 0.98-1.67) (Scott).

Smoking is a recognized causative factor for disc degeneration and nicotine plays a role on central pain modulation, therefore, back pain is also considered to enhance nicotine addiction (Scott, Battie 1991, 1995, Holm). Degenerative changes in smokers versus non-smokers have been observed in plain x-rays and at MRI in identical twins (Battie 1991, 1995).

In vivo and in vitro studies demonstrated the effect of smoke and nicotine on bone and joint tissues. Tobacco exerts a detrimental effect on disc degeneration: smoke blocks hemoglobin production thus reducing oxygen transport, vasoconstriction contributes to the lack of oxygen too. Furthermore, an impaired fibrinolytic activity is responsible of the reduction of trans-vascular transport of nutrition in the intervertebral disc. In vivo studies showed that acute smoking exposure produces capillaries constriction around the intervertebral disc and a marked reduction of oxygen ad glucose levels in the nucleus pulposis (Holm, nih.gov.disc). The model suggested by Elmasry confirmed that there are two main mechanisms involved in disc degeneration: a nicotine mediated down regulation of the cell proliferation and anabolism, and a reduced solute delivery at the intervertebral disc, due to vasoconstriction of the blood vessels surrounding the disc. They act in different disc regions at a different extent (nih.finite element). Quitting smoking has limited effect on potential regeneration (nih.finite element).

Smoking and Spine Surgery

Blood loss is a typical complication of spine surgery, increased blood loss may lead to transfusion thus exposing the patients to infections and other potential complications.

Smoking is known to cause alteration in vascular homeostasis and on the normal clotting cascade. In comparing two identical patients, one pack per day smoking, was associated with almost 330 mL more operative blood loss for smokers compared to non-smokers. According to these results it is recommended smoke quitting before spine surgery and blood conservation technique for current smokers patients undergoing spine surgery (MCunniff).

Another potential complication of spine fusion is pseudarthrosis occurring in 30 to 60% of patients. In vivo and in vitro studies showed controversial results regarding nicotine effects on spine fusion outcomes. Silcox used animal models to find no solid fusions in those exposed to nicotine (Silcox). After developing an in vitro model, the nicotine stimulation didn't affect the outcome of spine fusion study (Silcox). After finding no relationship between nicotine stimulation and spine fusion outcome the authors of a randomized controlled using a nicotine exposure model hypothesized a dose response effect of nicotine on bone healing after spine fusion (France). Glassman and co-authors found in a cohort of patients needed spine fusion who were surveyed for smoke habits before and after surgery, that post- operative smoking cessation markedly altered the non-union rate. Non-smoking patients, the non-union rate was 14% compared to the 26.5% of non-unions found in the currently smoking subjects. Current smokers (including patients who continue smoking even after surgery) underwent spine fusion mainly for mechanical low back pain and pseudoarthrosis while non-smokers had higher rate of degenerative collapse. Preoperative smoke cessation and the smoke amount didn't result to influence the non-unions events (Glassman).

Information about smoke habits could be hard to collect and retrospectively analyzed, in everyday clinical practice there is often missing information, for example, when patients are former smokers. In regards to smoke effects, it is worth to investigate the potential effect of smoking in current smokers, distinguished from former smokers and never smokers as done recently by Jazini and colleagues (Jazini). Former smokers had baseline and 12 months post-operative reported outcome that were in between those reported by current and never smokers. In the group of patients undergoing decompression, the score of the Oswestry Disability Index was worse in current smokers. There was a significate negative correlation between smoke-free days before surgery and baseline back pain at the Oswestry Disability Index and 12 months' leg pain.

Number of days without smoking can be considered a potential complication protector, but no precise data are available yet.

In 2016, Martins found that current smokers had significantly higher risks for wound complications and overall 30–days' morbidity after lumbar spine procedures than never smokers. In Martins' cohort the risk in former smokers trended higher according to smoking history: the shorter the duration of smoking cessation the higher the risk for post-surgery complications (Martin). Martin and colleagues defined as "former smokers" those who quit smoking more than 12 months before surgery.

The currently available evidence suggests considering smoking among all the other potential risk factors when planning surgical procedures. The guidelines for spinal fusion include smokers in the high-risk group of patients for non-unions complications together with patients who are undergoing revision surgery, and those suffering from other medical conditions (Groff). This needs to be better sorted out in future studies.

Osteoporosis

Osteoporosis is a condition of the skeletal system that is characterized by low bone mass and deterioration of bone tissue, leading to decreased bone strength and increased risk of fracture. Osteoporosis is especially dangerous since it is a "silent" disease—most individuals are unaware that they are at risk of fracture until one occurs. Thus, bone strength is an important part of an individual's overall skeletal health, and when assessing that health, two inter-related features should be focused on---bone mineral density (BMD) and bone quality. Bone mineral density tests, such as dual-energy X-ray absorptiometry (DXA) determine bone density by assessing the quantity of calcium and phosphorus within the bone. With regards to bone quality, body regions with high cancellous or trabecular bone content, are most affected by osteoporosis because of their more flexible and less dense structure as compared to cortical bone. Thus, fractures of the spine, hip, distal forearm, proximal humerus, and pelvis are the most common. As expected, the risk of fracture is highest in individuals with the lowest bone mineral density, however, fractures can occur in any individual whose bone mineral density is less than the norm. Both men and women can be affected by low bone mass, but women are at highest risk since bone loss is most rapid in the first few years after menopause and continues into the years following.

Defining Osteoporosis

According to the World Health Organization (WHO), a definition of osteoporosis is based on the level of BMD. Normal BMD is within 1 standard deviation (SD) of the mean level for a reference population of young adults with a corresponding T-score at -1.0 and above. When individuals are between 1.0 and 2.5 SD below that of the mean young-adult reference population, they are considered to have low bone mass or osteopenia (T-score at -1.0 to -2.5). Osteoporosis is ≥2.5 SD below the mean level for a young-adult reference population, with severe or established osteoporosis, considered to be more than 2.5 SD below with one or more fractures (Cosman).

While a diagnosis of low bone mass is relevant to any individual, it is especially important for those considering or requiring spinal surgery, due to the complications and long-term sequelae that can occur with unhealthy bone. Since individuals undergoing spinal surgery are typically older in age, they are at greatest risk for these outcomes--risks that include fractures, instrumentation failure, and proximal junction kyphosis. Therefore, it is important that spine surgeons consider a course of care for these patients prior to their surgeries; a course of care that is consistent with the patient's level of bone density and risk for detrimental long-term effects, since bone mineral density can influence surgical options, complications, and possibly the need for revision surgeries (Nguyen, Meredith, Uei).

The Fracture Risk Assessment Tool (FRAX®) is a fracture risk calculator commonly used in the clinical environment that estimates the 10-year probability of an individual incurring a major osteoporotic fracture. The FRAX® screens for 10 risk factors: sex, age, body mass index (BMI), prior fracture, parental hip fracture, prolonged glucocorticoid use, rheumatoid arthritis (or other secondary causes of osteoporosis), current smoking and alcohol intake, and femoral neck BMD. Unfortunately, the FRAX® does not include a patient's history of falls, and it underestimates fracture risk in patients who are at an increased risk of fall. Because of this, it is suggested that the FRAX be used for individuals without a history of falls, and that other prediction models, such as the Garvan Institute's Fracture Risk Calculator be used for those at significant risk with a history of falls (Bolland). https://www.garvan.org.au/bone-fracture-risk.

FRAX (Fracture Risk Assessment)

Table 3: Fracture Risk Assessment Tool (FRAX) (Kanis)		
Risk Factors		Results
Age	Current smoker	10-year Hip fracture risk (%)
Gender	Glucocorticoid use	10-Year major osteoporotic fracture risk (%)
Height	Rheumatoid arthritis	
Weight	Secondary osteoporosis	
Prior fracture	Alcohol >= 3 units / day	
Parent with hip fracture	Femoral Neck BMD (gm/cc) or T-score (FRAX may be calculated without BMD data)	
Treatment Criteria (Cosman)		
Hip fracture risk > 3% or Major osteoporotic fracture risk > 20%		
Screening Criteria to determine who should have DXA based on FRAX with BMD (US Preventive Task Force)		
Major osteoporotic fracture risk > 8.4%		

Epidemiology of poor bone health in spine surgery

In primary spine surgery low bone mass and vitamin D deficiency are common and likely worse in revision surgery cases. Vitamin D deficiency (25(OH)D < 20 ng/ml) occurs in 30-65%, while 27-40% (25(OH)Vit D 20-30 ng/ml) of patients, are insufficient. Osteopenia is present in 30-50% and osteoporosis 10-20% of patients (Anderson).

Hills retrospectively reviewed the role of endocrine disorders in 169 patients with pseudoarthrosis after spinal fusion. Overall endocrine disorders were present in 82 % of patients and endocrinology referrals were made in 59 (34.9%)of patients (Hills). Osteopenia and osteoporosis were the most common endocrine disorder; where prior to referral 18.9% were diagnosed and after endocrinology assessment this increased to 45%. Vitamin D deficiency was also highly prevalent, occurring in 38% of patients. Other endocrine disorders likely affected skeletal function included diabetes (27%), hyperparathyroidism (5%) and sex hormone deficiency (18%).

Adverse consequences of poor bone health

Adverse consequences of poor bone health result in poorer outcomes and complications often leading to secondary surgery, Table 1. Bjerke reported fusion success and bone related complication in 140 patients undergoing lumbar spinal fusion.[1] He found that osteoporotic patient had a 50% rate of nonunion compared to 18% of those with normal bone. Osteoporotic related complications including hardware failure compression fracture kyphosis and nine union occurred in 19, 28 and 67% of patients. Other complications that have been reported related to osteoporosis include screw, cage subsidence, increase spondylolisthesis, sacral and pelvic insufficiency fracture, durotomy, and revision surgery, Table 1.[2-20]

Table 1 Adverse effects of poor bone health on outcomes of spine surgery	
Nonunion	Bjerke[1], Cho[2]
Screw loosening	Bjerke[1], Sakai[3], Bredow[4]
Hardware failure	Bjerke[1], Bernstein[5]
Interbody cage subsidence	Formby[6], Tempel[7,8]
Proximal junctional fracture	Uei[9], Meredith[17]
Proximal junction al kyphosis	Yagi[10]
Increase spondylolisthesis	Wang[11], Andersen[13]
Increased scoliosis	Yu[14]
Revision surgery	Bjerke[1], Shue[15], Puvanesarajah [16]
Pelvic and sacral insufficiency fractures posterior fusion	Meredith[12], Papadopoulos[18], Odate[19], Klineberg[20]
Compression fracture	Formby[6]

Preoperative screening for osteoporosis

Identification of patients with osteoporosis has proven difficult especially by surgeons who are not familiar with indications for BMD testing. Further there is a false expectation that this is a role for primary care, which unfortunately screens less than 10% of patients with current guidelines. Therefore, the surgeons must assume the responsibility to apply presurgical screening process and to interpret DXA. If there is low bone mass than a referral to as specialist or fracture liaison service (FLS) type of service should be considered.

All patients 50 years and older who are undergoing thoracolumbar spine surgery should be assessed to determine if they should have a DXA before surgery. Since many of the revision's surgeries may be associated with osteoporosis, screening in this group is of particular importance. The screening process can be performed by the surgeon or nursing personal. We utilized a checklist consistent with current guidelines, Table 5.

In the revision surgery case, in addition to the screening criteria a failure analysis should attempt to identify potential causes one of which may be poor bone mass. Findings include any postoperative fracture, screw loosening, cage subsidence, increased spondylolisthesis or deformity, insufficiency fracture, and proximal junctional kyphosis. In addition, patients are assessed for fall risk, given recommendations for nutritional supplementation, examined for malnourishment and sarcopenia, and educated regarding risk of complications from poor bone health if warranted.

Table 5. Bone Health Optimization

Checklist	Goals	Timing
Screening	Identify patients who need further BMD screening	At initial surgery scheduling or first office visit
Nutritional supplements	Replace Calcium, Vitamin D and protein as needed	At initial surgery scheduling or first office visit
Fall risk assessment	Nutritional assessment and TUG and grip strength	At initial surgery scheduling or first office visit
Patient education	Inform patients of association with fall risk poor outcomes and future fractures related to osteoporosis	At all stages of pre-operative evaluation
DXA/ Opportunistic CT	Measure bone mineral density, estimate risk of osteoporosis	At initial surgery scheduling

Referral to bone health specialist/ FLS	Screen for secondary causes Assess 25(OH)D Recommend medications as needed	For patients with abnormal bone mineral density: Osteopenia or osteoporosis
Treatment of osteoporosis	Anabolic agents if possible	Start before surgery and continue for full treatment
Surgical delay	Discuss between surgeon and bone health specialist regarding efficacy of delay until bone health optimized	Ranges from 3 months for simple surgery to 9 months for complex multilevel or osteotomy or revision

Bone Health evaluation in revision spine surgery

An essential component of the evaluation of a postoperative patient is an analysis of the original indications, comorbidities, postoperative course, and structural changes since surgery. Bone health is likely to be a factor and therefore should be completely evaluated before further surgery. Bone health evaluation consists of screening to determine if bone densitometry is warranted, identification and treatment of vitamin D and calcium deficits, assessment of nutritional state, and analysis of falls and generalize muscle weakness. Unfortunately, the spine surgeons' attitude toward screening for osteoporosis is relatively poor with only 19% of surgeons reporting that they check DXA when evaluating patients with pseudoarthrosis (Dipaola).

Surgical delay for bone health optimization

Referral for and treatment of poor bone health may require surgical delays. However, this requires timely completion of diagnostic tests and institution of treatments. This is a shared decision process between the surgeon, bone health specialist, and patient. Patients with urgent condition such as neurologic deficits should rarely have delays to optimize bone health, in these cases postoperative care can be instituted.

If a delay is possible then the duration is dependent upon the requirements imposed on the skeleton, need for bone fusions to occur, and relative risks of surgery. No data is available that provides an indication as to the optimum

number of months of treatment before surgery can take place and recommendations are based on known of mechanism of action of the medications, evidence from treatment of fractures, and biomechanical studies.

Treatment with both antiresorptive and anabolic agents result is skeletal changes that can be measured within 3 months including increased bone mineral density and lower fracture rates between placebo controls and treatment groups (Cosman). By 12 weeks, bone turnover markers have optimized indicating that desired responses to treatment has occurred (Cosman). In addition, Inoue has shown in RCT that pedicle screw insertional torque was significantly better in osteoporotic patients given teriparatide compared to placebo controls after only 2 months of treatment (Inoue). Further finite element studies based on spinal CT show a 10 % increase in bending strength with romosozumab at 3 months (Keaveny).

No surgical delay

Delay of Surgery is not indicated when there are urgent indications such as neurologic changes, rapid progressive deformity, and for treatment of fractures. In addition, simpler cases such as laminotomy without significant removal of bone and discectomy likely do not need surgical delay.

Short term delay – 3 months

The author recommends 2-3 months of pretreatment of osteoporotic patients before undergoing wide decompression for spinal stenosis and 1-2 posterior level fusions. Treatment will be continued after surgery.

Long delays – 6 to 9 months

Osteoporotic Patient having revision surgery and these undergoing multilevel arthrodesis or spinal osteotomy should be more aggressively treated before surgery. Six to nine months of pretreatment maximizes increases in bone mineral density and creates a more receptive bone that may enhance healing. In addition, correction of nutritional and vitamin deficits promote bone healing and may avoid postoperative falls.

Preserving strength and bone density

Weightbearing and muscle-strengthening exercise is recommended to reduce fractures and falls and to preserve bone density. These types of exercise have a variety of benefits including, but not limited to improving motor control and muscle strength (Bennell), static and dynamic posture, balance, and reduction of fall risk. Specific exercise programs, including mixed or varied loading can preserve BMD in pre and postmenopausal women (Cosman). Examples of effective mixed loading include jogging with other low-impact activity such as stair climbing or walking and impact activity with high-magnitude exercise such as resistance training. It should be noted that walking alone has not been found to be effective for preserving bone in postmenopausal women and therefore, programs that

combine varied approaches are best (Martyn-St James). In order to reduce falls, programs should include both muscle strengthening that increases muscle mass and balance exercises (Sran, Palmer). It is important to understand that fall-prevention programs alone do not necessarily increase strength (Madigan).

Postural education and retraining is necessary for individuals with low bone density since thoracic posture influences spinal loading (Duckham). Observation of movement during functional tasks stresses optimal and safe movement patterns and the avoidance of high risk movements such as forward bending with the trunk in flexion and rotation. Determination of the need for an assistive device and education on proper bending and lifting ergonomics helps individuals avoid vertebral compression caused by excessive loads being applied to the spine. (Camacho)

Individuals with osteoporosis and osteopenia, if hyperkyphotic, will benefit from the exercises previously discussed in the section on spinal deformity.

Adult Deformity Bracing

While spinal orthoses, especially the rigid hyperextension thoracolumbar brace, have typically been used for patients with compression fractures, there is limited evidence concerning spinal orthoses for vertebral osteoporosis without compression fractures. Currently, the evidence for using orthotic devices and/or taping for individuals with osteoporotic vertebral fractures is inconsistent and of limited quality, which makes clinical decision-making difficult (Newman). Three recent studies may be of interest to those working with individuals with osteoporosis and/or vertebral fractures. An 2017 article by Meccariello and colleagues concerning the use of a dynamic corset versus the typical three-point orthosis in the treatment of osteoporotic compression fractures showed greater pain reduction and improved quality of life with no difference in stabilization. An 2018 article studied the effects of an adhesive postural taping device on pain and function compared to usual care with individuals diagnosed with an osteoporotic vertebral fracture. The taping device appears to have the potential to decrease pain and increase function but needs a subsequent trial with greater power (Palmer).

A 2017 study evaluated the effects of the Dynamic Hyperextension brace on bone density and correction of hyper-kyphosis in postmenopausal osteoporotic women that they followed for one year. They reported that BMD and kyphosis were significantly improved in the brace treatment group and concluded that bracing in osteoporosis should be more emphasized (Shariatzadeh).

The problems associated to adult spine deformities are back pain, disability, progression of the deformity, and aesthetics (Glassman, Palazzo).

When there is evidence of scoliosis progression, bracing is indicated before surgery. Effectiveness of bracing in reducing progression after a minimum period of brace wear of 10 years was reported in a cohort of 38 patients with adult scoliosis (Palazzo). Some useful indications came from Palazzo's study: bracing should be prescribed

according to patient's needs. A medium to long-term pain relief and postural support could be expected. The minimum dosage is 4-6 hours, for a minimum period of 6 months and then gradual reduction to "as-needed" wear. It is recommended to wear brace while active i.e. during day at work. In cases of severe pain and demonstrated progression of scoliosis it is recommended to increase dosage to 6-12 hours per day and if tolerated and accepted, permanent treatment.

Evidences regarding these recommendations are poor, and some drawback in brace use should be considered too: considering that the average progression in adulthood is very small compared to a very large measurement error, longer follow up are needed to really understand the long term effect of bracing, therefore cautions must be maintained for younger patients. Full time brace wear could have some adverse effect on muscle strength thus making the patients "addicted" to brace; this is an important drawback particularly for younger patients. In this view physiotherapeutic specific exercises would be really helpful in avoiding bracing side effects and would guarantee a better compliance to the prescription. The reported recommendation for brace use and prescription are strongly correlated to the expected drawback of full time use, considering also that until now no one investigated bracing side effects in the long term.

In some cases, bracing is provided for pain relief, but again scientific data are sparse even on the effectiveness of brace in reducing back pain, and nothing is known about trunk support.

Multiple brace types are available, soft, and rigid from very low rigidity to hyper-rigid bracing. Sometimes patients prefer passive treatment and choose to wear a brace but avoid exercises, this could represent a threaten to scoliosis progression. In other cases, it could be challenging to make patients wearing a brace, discomfort and difficulties or limitations in everyday life activities cause poor compliance. Movements are limited and sometimes wearing a brace does not relieve pain. Braces have also an aesthetic impact which often concerns adult and elder patients, and last, but not least braces could impact breath function and generate eating disorders. Furthermore, braces are sometimes difficult to be self-wore correctly; therefore the need for assistance is another reason for poor compliance.

Effects of Long Fusions on ADL's

It appears that many patients, especially older ones, do not comprehend the effects of a long spine fusion on ADL's, especially in the presence of hip or/and knee arthritis. There are numerous papers looking at this.

Falls/Frailty

The Clinical Guidance Statement (CGS) from the Academy of Geriatric Physical Therapy (AGPT) of the American Physical Therapy Association, "Management of Falls in Community-Dwelling Older Adults"

1. Physical therapists should provide an individualized assessment within the scope of physical therapist practice that contributes to a multifactorial assessment of falls and fall risk. Additional potential risk factors may need to be addressed by the appropriate provider as indicated (CGS Grade A: Strong recommendation based on Level II evidence). This assessment should include:
    a. Medication review with emphasis on polypharmacy and psychoactive drugs
    b. Medical history with emphasis on new or unmanaged risk factors:
        i. Osteoporosis
        ii. Depression
        iii. Cardiac Disease, including signs or symptoms of cardio-inhibitory carotid sinus hypersensitivity
2. Body functions and structure, activity and participation, environmental factors, and personal factors:
    a. Strength
    b. Balance
    c. Gait
    d. Activities Of Daily Living
    e. Footwear
    f. Environmental Hazards
    g. Cognition
    h. Neurological Function
    i. Cardiovascular Function, Including Postural Hypotension
    j. Vision
    k. Urinary Incontinence

Fall prevention is a major goal when working with individuals with low bone density. Addressing strength and balance issues as described above is necessary to prevent falls. Environmental factors, such as lack of handrails for support, slippery floor surfaces, and throw rugs are important to address as they can lead to falls, but there are several other factors that are commonly missed (Cosman). Low level lighting, lack of assistive devices in bathrooms, visual impairments, decreased mental acuity, urgent urinary incontinence, and multiple medications can all be sources contributing to increased fall risk. For individuals who have low bone density and are at risk for fracture and/or falling, referral to a physical therapist for determination of a safe and effective exercise program along with activity and movement education and fall risk assessment is important for long-term skeletal health.

Sarcopenia and Fall Risk

Revision spine surgery often involves patients with extremes of weight, low body mass and morbidly obese. An assessment of the nutritional state is important as malnutrition is associated with osteoporosis and risk factor for complications and optimization before surgery should be considered. To address bone health, it is recommended that patients consume 0.8 to 1.2 mg/kg/day of protein. [24]

Sarcopenia is a term describing both a loss of muscle from atrophy and fatty replacement, and a functional deficit. Sarcopenia and other like condition such as frailty are strongly associated with surgical morbidity and mortality in spine patients. Further sarcopenia is linked to fall risk, which often leads to revision surgery or poor outcomes after revision surgery. There is a link between sarcopenia and osteoporosis that has been termed dysmobility syndrome (Buehring). This syndrome can ultimately result in falls, fractures, and in the spine surgery patient failure of the procedure. Assessing fall risk and nutritional are essential components of bone health assessment. Optimization as needed and referral to physical therapy may be indicated preoperatively.

Falls risk is critical to address before revision surgery. The CDC recommends asking three questions (CDC 2018).

- Do you feel unsteady when standing or walking?
- Do you worry about falling?
- Have you fallen in past year

Some simple tests of fall risk can be performed in the surgeon's office.

- The Timed up and Go test (TUG) measures the time to arise from a seated position, walk three meters, turn around and sit down. Fall risk is an associate with TUG greater than 12 seconds (CDC 2019)
- Grip strength can be measured by a dynamometer; males should have grip strength > 32 kg and females > 22 kg (Bahat). Shen has demonstrated that increased grip strength is a positive predictor of outcome of spine surgery (Shen)

Patients with these functional deficits should have assessment of nutrition and address falls risk with perioperative rehabilitation. Also, knowledge of the fall risk may aid is postoperative rehabilitation goals such as need for skilled nursing facility.

Stress

David Hanscom, MD (Lead); Kevin Cuccaro, MD, DO; Geralyn Datz, PhD; Joel C. Konikow, MD; Frederic Luskin, PhD; Drew Sturgeon, PhD; Loren L. Toussaint, PhD*

The Problem

Only 15% of primary care physicians enjoy treating chronic pain (Marcus). This is understandable in light of the fact we are not trained well to deal with it and are also being taught the wrong treatment paradigm in light of the last 10 years of neuroscience research. (Rice, Mansour)

One basic problem is that doctors are trained to treat chronic pain "psychologically" if a structural explanation for the pain is not identifiable. Most pain does not have an identifiable source, yet there are over 100 million people in the US suffering from chronic pain. There is something else going on.

Historically, many patients were referred for psychological evaluation before a procedure. However, it often was just an assessment without a definitive treatment plan. The bigger problem is that it turns out the problem is multi-factorial and not primarily psychological. The key is whether nervous system is sensitized from sustained levels of stress chemicals. Since this hormonal stress response (anxiety) is the core of the unconscious survival response, rational interventions cannot and do not work in isolation. The unconscious brain processes about 11 million bits of information per second and the rational brain deals with only 40 bits per second (Trinker). Pain is just one of the signals that says, "danger", which creates a stress response. When trapped by chronic pain, the exposure to these

chemicals is sustained and multiple physical symptoms are the result because each organ system responds in its own specific way (Abbass, 2015).

Regardless of the exact source of chronic pain, the key is to normalize the body's chemistry to neutral or relaxed. There are multiple effective strategies, some of which are outlined below. The adverse effect of anxiety, anger, depression, catastrophizing, and fear avoidance on treatment outcomes have been documented for over 50 years in thousands of research papers. Yet a 2014 paper out of Baltimore showed that fewer than 10% of surgeons were addressing these issues prior to recommending surgery (Young).

Psychosocial Well-Being

Background

Pathologic levels of stress, anxiety, sleep deprivation, depression and a number of other factors adversely affect patient well-being. These are common disorders in North America and if not addressed proactively adversely affect patient outcomes.

Deranged living circumstances are also common occurrences in this era of further fragmentation of families and living arrangements. With an increasingly elderly population these factors adversely affect length of stay and can lead to unsafe circumstances for families post discharge.

Concerns arise about patients who present to medical care in the midst of major personal losses. Major elective surgery is preferably undertaken after major life stressors have been processed. It is important to identify such patients in these life stressors prior to engaging in elective surgeries and help direct them towards constructive resolution of their circumstances.

Similarly, it is in everybody's' best interest to identify mental illness. Undoubtedly, it is important to define this variable and have patients engaged in active treatment prior to engaging elective spine surgery.

Specific Hypothesis:

Improvement of personal, environmental, and societal psychosocial variables will improve likelihood of a favorable outcome in the short and long term and positively influence patient satisfaction. These variables should be the focus of the initial sets of patient/ provider interactions.

Deliverables:

Routine (preferably digitized) psychometric testing pre and postoperatively.

1. Cognitive
2. Behavioral
3. Environmental
4. Emotional
5. Anxiety/ Anger/ Depression

Measurable positive effects of intervention are expected prior to elective spine surgical intervention.

Importance of the Physician-Patient Relationship in Healing

Joel Konikow, MD

Thinking in terms of a team approach is important in all chronic medical problems. WE must strive to be open and curious and interested in helping our patients who come to us seeking help.

How can we combine our knowledge and desire to help those we see in our work and allow them the best treatment and opportunity for healing? The following discussion and recommendations share what I have learned and applied to accomplish these goals in the process of understanding the medical diagnosis for each patient I saw and for finding a path for each patient to maximize their health.

Listen to the story. Each person has a story to tell and as I learned in medical school the story is the key to understanding both the illness and how this particular person conceives of needing help. By providing a space for the patient to tell his or her story, right from the beginning at the first visit, we begin the process of creating a safe place and a listening ear on both sides and building mutual trust.

We need to provide adequate time for the initial visit and subsequent visits. This is in my mind the single most important foundation for a healing and positive relationship. I had the good fortune to be able to schedule new patients for a one-hour visit for almost my whole career. The four years I worked at a health maintenance organization I learned that fifteen-minute appointments were not adequate for most visits. I was then a primary care physician.

We need to develop a patient centered approach. We may know the diagnosis, or think we know the diagnosis, even before we meet the patient, or in the first few minutes of our visit, but the person always must be given adequate time to tell their story. Therefore, just listening quietly and intently for the first few minutes of a visit is crucial and powerful. I learned to breathe and to center myself and take a brief few moments to do this before coming into a room to start each visit. It is important to continue to do this periodically during an appointment to keep focused for the patient. To

respond rather than react, by taking a few moments to continue listening and being quiet, is especially important when the emotions expressed feel charged with energy that may be more difficult to handle. Dr. Mark Tomski taught me this important understanding.

I discovered that motivational interviewing is an indispensable aid to meet the goals of listening, helping people change toward a healing path, and for developing empowerment and an internal locus of control for patients. It teaches a very positive way to listen to patents, teaches us how to focus on the patient and her or his desire to change and how that might come about. Motivational interviewing is not a technique but rather an ongoing process for us to develop and refine for an ongoing mutuality in developing goals and ideas for care and caring.

Not long after I joined Swedish Pain Services all the staff at the clinic attended a several hour in-service workshop that explored how we can best interact with and have a therapeutic relationship with patients who present us with difficulties and where the relationship between patient and physician or other medical personnel is fraught. I do not recall the name of the psychologist who presented and gave us the following advice. He said, “The patient is not the problem. The problem is the problem.” Patients come in with many problems and often will express frustration or anger. Not infrequently, we may feel overwhelmed or have some other reaction to the patient regarding what he or she brings with them in their interactions. We must remember that the patient we are sitting with has a problem or problems they are coming to see us about for help, and that they themselves may present other problems and issues with which we must work in order to help them. They themselves are not the problem. I have found this a powerful way to be aware of countertransference and prevent it from occurring. A person may present a very complicated set of issues we need to navigate in helping them and there is a tendency to say, “This is a difficult patient.” The problems patients present us with may be tough or difficult, but we should not impugn the patient in this regard. This teaches humility on our part, and respect for the patient and helped me adjust my own thoughts and relationships with the patients with whom I worked.

This brings up another point that is crucial to successful work in medicine. I came to understand that the interactions with patients could change me for the better. The mutuality that the work in chronic pain demanded allowed me to treat myself in a healing manner. By working with the concepts of cognitive behavioral therapy and mindfulness meditation, which we teach to patients in chronic pain, by applying motivational interviewing in my practice, by increasingly learning to listen better, I found growth for myself as well as for my patients. This left me with a feeling of empowerment, which felt very good, and I often experienced joy at the end of a workday. David Hanscom and I talked about this often. The patients did not all need to agree with my recommendations, but even if they might be disappointed for one reason or another, or if I felt disappointed, the relationship itself, and the interaction, was almost always positive.

Lastly and importantly is the idea that not only do we need to give adequate time at the visits for each person we work with in clinic, but we need to allow time for patients to change, to heal, to understand how to incorporate change and new ideas into their life. Once a patient comes in to see me, there was no time limit on how long we could work together. Swedish Pain Services is a tertiary clinic where patients are seen by referral. Increasingly we began to see patients over a longer time so that the ideas I have outlined above could take root and allow healing, whether that meant resolution of pain, or better management. By managing the pain issues and actively working with the other

physicians and care-givers the patient could grow at their own pace, and feel physically, emotionally, and mentally more comfortable.

David Hanscom asked me to write recommendations relating to the physician-patient relationship and its importance in healing. David was my mentor and colleague during the years I worked at Swedish Pain Services in Seattle, from April 2010-March 2018. We worked closely together to communicate and build a team to allow healing for patients with chronic pain. David worked at the Swedish Neuroscience Institute Spine Center. I owe a debt of gratitude also to Dr. Gordon Irving who was the director of Swedish Pain Services at the time and who, along with David, encouraged me as we continued to learn new and better and safer ways to help people heal from chronic pain, or at least to help them feel more comfortable and have a better quality of life. I also owe a debt of gratitude to Sally Buslach, RN, our nurse manager at the pain clinic who also supported the efforts to learn better ways of working with patients with chronic pain. Without this encouragement and support, including my other colleagues and staff, the work we did would never have gotten off the ground.

Role of Patient Education

Kevin Cuccaro, MD

While the science of pain has progressed tremendously over the last 20 years, these advancements have not been publicly appreciated. For example, many pain patients incorrectly believe pain is correlated directly to tissue damage (Setchell). Unfortunately, these structurally based pain beliefs are associated with worse outcomes (Baird) and decreased compliance with less invasive, active therapeutic modalities (Hendry, Rowe).

One possible reason for this is that if organic pain beliefs are present then active based treatments may not make sense to the patient. More specifically, active based therapies require patient engagement with the treatment for that therapy to be successful. However, the patient may not engage because the proposed treatment contradicts their beliefs about their pain. For example, if the belief, “Pain equals damage!” is present and movement is associated with pain (e.g., “I’m damaging my back more!”) then it makes sense for that patient to not comply with, if not resist, movement based therapy recommendations.

Similarly, if a patient believes their experience of pain arises directly from physical injury, asking them to engage in a psychological therapy (e.g., CBT) conflicts directly with that pain belief (“My pain is REAL but you’re saying it’s all in my head!”). The reason these patients then do not participate may not be because they are inherently non-compliant or resistant to improvement but because the therapeutic regimen does not make sense to them. So why should they participate? Thus, if these underlying pain misconceptions are not recognized or addressed, patients may choose to not pursue or participate fully with recommended or referred therapeutic modalities (Setchell, Baird, Hendry, Rowe).

For the clinician, understanding up-to-date pain neuroscience is even more important. Clinician pain misconceptions and structural based pain beliefs are associated with less adherence with evidence-based guidelines and, in turn, influence the development of structural-based pain beliefs in their patients (Darlow, Lin, Moseley, Louw).

This is why incorporating pain education early into the clinical encounter is important for practice, particularly, when the experience of pain is the primary target of care rather than a structural defect.

That is pain neurophysiology education is less important in the presence of an acute structural defect with neurologic injury and worsening deficits. In that scenario, urgent attention to those deficits is paramount whether or not pain is present and education less warranted. However, when the primary reason for the visit is pain without new or progressive neurologic injury then incorporating up-to-date pain education is warranted.

Ideally, early intervention with up-to-date pain neurophysiology education could counter or prevent these misconceptions from developing (Lin, Darlow) and help patients reconceptualize their pain beliefs from a strict structural/biomedical paradigm to a more comprehensive biopsychosocial phenomenon (Mosely, Louw). In addition, pain neurophysiology education delivered in combination with active based therapeutic strategies has been found to improve treatment outcomes (Louw, Geenen). These outcomes are especially profound given the lackluster cost/benefit ratio found with many widely used pain treatments (Friedly, Deyo).

Expressive Writing

David Hanscom, MD

Research on expressive writing began in the 1980's. Pennebaker documented a positive effect on both physical and emotional well-being. His experiment involved asking college students to spend 20 minutes four days in a row. One group was asked to simply write about life events and the second group was asked to focus on intense emotional experiences. Four months later, significant improvements were noted in the following areas (Baikie):

Health Outcomes

1. Fewer stress-related visits to the doctor
2. Improved immune system functioning
3. Reduced blood pressure
4. Improved lung function
5. Improved liver function
6. Fewer days in hospital
7. Improved mood/affect
8. Feeling of greater psychological well-being
9. Reduced depressive symptoms before examinations
10. Fewer post-traumatic intrusion and avoidance
11. Symptoms

Social and Behavioral Outcomes

1. Reduced absenteeism from work

2. Quicker re-employment after job loss
3. Improved working memory
4. Improved sporting performance
5. Higher students' grade point average
6. Altered social and linguistic behavior

Additionally, there are beneficial effects on other chronic problems such as: asthma, autoimmune disorders, wound healing, irritable bowel syndrome, blood pressure, and chronic pain.

Overall, there have been over one thousand research papers (Pennebaker) looking at various approaches to the writing and the debate is not whether it has an effect, but what is the best technique for a given patient. It is simple cost-effective and effective intervention that should be routinely recommended in the context of chronic pain.

Optimism and Hope

David Hanscom, MD

A large review article of multiple research papers (Schiavon) documented a positive effect of hope and optimism in the presence of chronic disease on the following variables: severity of symptoms, mood, compliance with treatment, satisfaction with rehab, pain control, coping skills and healthier lifestyle. More work is needed on specific disease states.

Emotional Pain and Approach to Mood Disorders

Drew Sturgeon, PhD

For people with chronic pain, there may be a complex set of factors that initiate and sustain the chronic pain process. One particularly salient factor is a history of significant life stress or trauma. Among people with chronic pain, there appears to be a higher incidence of major life stressors and trauma. This pattern is also evident in the higher rates of post-traumatic stress disorder (PTSD) in chronic pain than in the general population. However, even when patients do not meet full clinical criteria for PTSD, they may have a significant history of being victims of abuse, severe conflict, or other forms of trauma. These major stressors can shape both patterns of future social interactions and also may have corresponding effects on brain circuits relevant to chronic pain, particularly those related to learning, memory, and emotion.

Recent efforts in psychotherapy research have highlighted the importance of helping patients with significant life stress and trauma to process the strong emotions that may have arisen out of these events in a safe way, which can ultimately allow the emotions to resolve. It is theorized that these emotions, if blocked or suppressed for an extended period, may alter the functioning of brain circuits related to chronic pain; indeed, evidence since the 1980s has

suggested that suppressed anger can worsen the experience and consequences of chronic pain. Thus, helping patients to recognize strong negative emotions as a normal and healthy process may help change the chronic pain circuit as well. This approach (most recently published under the term Emotional Awareness and Expression Therapy; EAET) has shown the ability to reduce pain and associated symptoms in a variety of chronic pain conditions, including abdominal pain and fibromyalgia.

Relatedly, it should be noted that the experience of pain itself, which can be a highly threatening and stressful experience, may ultimately begin to sustain itself through heighted emotional distress. As a result, people living with chronic pain may benefit significantly from interventions that help them regulate emotional distress that arises due to pain; if applied consistently, these techniques can improve not only mood and physical functioning but may also help alleviate the severity of pain in the future. There is a robust body of evidence suggesting that meditation approaches such as mindfulness-based stress reduction (MBSR) can reduce stress and emotional well-being in people with chronic pain and can also reduce the severity of pain.

Negative Emotions, Pain, and Forgiveness

Loren Toussaint, PhD (Luther College) & Frederic Luskin, PhD (Stanford University)

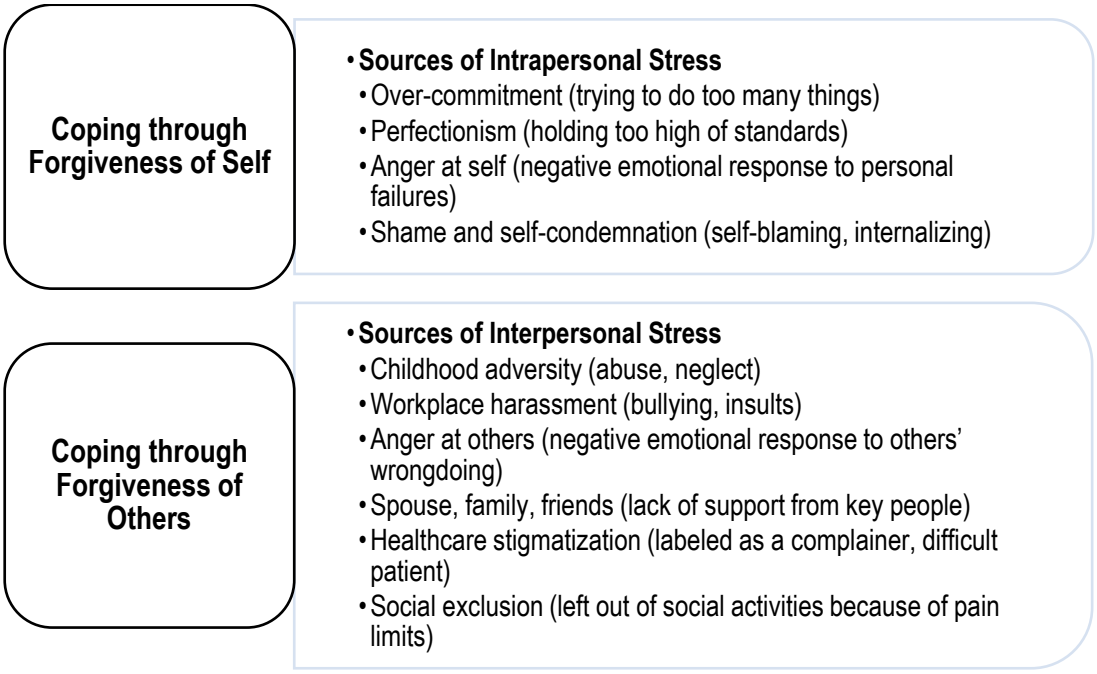
Negative emotions such as anger and stress have long been known to erode our quality of life, happiness, and health (Cohen). Examples abound where these emotions have shown themselves time and again to interfere with our enjoying and living life to its fullest. Stress is the experience of being overwhelmed and feeling as though one has lost control and can no longer cope with either daily life or major life events. Stress is known to interact with some specific genetic vulnerabilities to influence the severity of mental health symptoms (Conway), stress is widely known to impact our endocrine and immune system functioning in several ways raising risk for mental and physical health problems (Cohen, Graham, Slavich), and stress has been linked to mortality in men and women (Nielsen).

Another prevalent negative emotion is anger, defined as a strong negative emotional reaction to being treated unfairly, and it too has unhealthy associations with health and well-being, especially when it is expressed in highly emotional and intense ways (Iyer). For instance, anger has been connected strongly to poorer heart-health, mental health, and in some cases to diabetes, skin conditions, and irritable bowel syndrome. Take as a final example the role of hopelessness and hostility in a person's life. Hopelessness is the sense that little good will come from the future, and it is connected to heart problems, cancer, and earlier death (Everson, 1996). Hostility, on the other hand is a perspective that involves distrust, cynicism, and skepticism, and is related to a faster rate of cognitive decline and earlier death (Everson, 1997). There is simply no shortage of examples of how negative emotions interrupt otherwise good and prosperous lives by taking a mental and physical toll on individuals from all walks of life.

In addition to the significant chronic illnesses and diseases that negative emotions are connected to, negative emotions are also keenly involved in one of the most significant impairments to health-related quality of life in the modern day—pain. Chronic pain has been estimated to affect 11-40% of the United States population, and a recent estimate suggests that about 20% of the population experiences chronic pain while 8% experience high-impact chronic pain (chronic pain that limited life or work activities on most days or every day during the past 6 months) (J

D). Connections between pain and negative emotions are a two way street—pain sometimes results in feeling negative emotions and sometimes the reverse is true, negative emotions can lead to or exacerbate pain (Wiech). Some of the strongest evidence of this comes from interventions studies showing that nonpharmacological treatments for pain reduce both pain and negative mood (Malone), and studies aimed directly at reducing stress through meditative practices offer considerable pain relief for healthy individuals (Khoury) and patients of many types including back pain patients (Anheyer).

Given the prevalence of chronic pain and its impact on individual, family, and community quality of life, it is important to better understand effective coping strategies for chronic pain. While a good deal of effort has been devoted to this already (Fernandez, Jackson, Jensen), and the aforementioned mindfulness mediation practices are presently a popular and effective means of coping with and intervening to reduce chronic pain, other positively-oriented, strengths- and resilience-based aspects of life have long been overlooked (Folkman) As interpersonal stress and conflict is a common part of daily social and work life (CPP, Repetti). it is likely that these sources of stress, anger, and other negative emotions may elicit or aggravate chronic pain experiences (Faucett). Consequently, the ability to forgive may have important connections to the experience of chronic pain in modern life. In fact, one review outlined specific areas of interpersonal experience that are commonly a source of stress and conflict for chronic pain patients and also identified where self-forgiveness and forgiveness of others may be particularly relevant (Offenbacher). The diagram below summarizes this review.



Knowing how stress, anger, and other negative emotions can exact a toll on chronic pain and quality of life, the role of forgiveness in easing interpersonal stress and conflict and in helping to temper angry and hostile reactions to perceived injustice may offer an important route by which to manage otherwise aggravating factors in the experience of chronic pain. But what evidence might support such a supposition? First, stress-and-coping theories of forgiveness suggest that forgiveness is a primary response that can help to ameliorate negative emotional reactions to injustice

(Luskin, Toussaint 2017, Worthington). Although these theories are complex and lengthy explanations for how forgiveness is involved, the important point is that forgiveness, at its core, is the replacement of negative emotions and tendencies with more positive ones. Positive intentions in life can bring peace and calm amidst even the most tumultuous circumstances. Second, evidence from randomized controlled trials of Forgive for Good, one of the most widely used and storied methods for promoting forgiveness, shows that teaching people to become more forgiving does actually result in folks becoming more forgiving, but even more so it also results in less negative emotions like stress, depression, and anger and more positive ones like vitality, gratitude, and self-efficacy.[22,25-28] (Luskin 2002, Harris, Luskin 2005, Tibbits, Toussaint 2009). Third, theory suggests that for individuals with chronic pain conditions, forgiveness can serve as an effective mechanism that, in essence, short-circuits the untoward effects of stress, anger, and negative emotion on pain and other broader mental and physical health outcomes (Toussaint 2010). Fourth, empirical evidence suggests that individuals with chronic wide-spread pain who report higher levels of forgiveness also tend to report lower levels of pain, and individuals with chronic low back pain similarly show that those with higher forgiveness also experience less pain (Carson). Finally, in one intervention study of chronic wide-spread pain patients, learning to become more forgiving resulted in less experienced pain Lee). In summary, theoretical and empirical evidence weigh in favor of forgiveness as an effective means of coping with chronic pain.

Knowing that forgiveness has beneficial relationships with chronic pain, the obvious question is how to promote forgiveness in these patients. This is not an easy question to answer, but thankfully there are groundbreaking methods of teaching forgiveness that can be applied. One such method that is particularly useful for chronic pain patients because of the direct inclusion of stress relaxation (including deep breathing, guided imagery, and integrative and meditative techniques) in addition to more standard cognitive restructuring techniques, is the Forgive for Good (Luskin 2002) method. The Forgive for Good method of promoting forgiveness has been used to teach literally thousands of people from the United States, Europe, Africa, Columbia, and other countries how to forgive. Forgive for Good methods have also been used with heart patients and chronic pain patients and have been shown to be effective and well-received in these patient groups.

Medication Management

Marilyn LG Gates, MD, MBA (Lead); Turgut Akgul, MD; Gordon Irving, MD; Mel Pohl, MD*

Opioids

Although there is little evidence that opioids are useful in chronic pain as shown by double blind studies at the VA, the fact remains that many patients with a chronic musculoskeletal problem may be taking them (Zedler). The opioids may be taken on a daily basis or intermittently for flare-ups. The latter probably has less concern regarding the negative effect on surgery

Although the opioids as a class work on the opioid receptors, there are at least three general classes of opioid receptors, termed:

1. Mu
2. Kappa
3. Delta
4. Nociception opioid (NOP) receptor.

There are several subgroups with each type of receptor. Given the physical differences in lipid solubility, their different ways of absorption, metabolism, and excretion, it should be no surprise that there are significant inter-individual efficacies of each opioid.

The Concerns with Pre-Operative Opioids

1. Opioid induced hyperalgesia:
   a. This creates increased sensitivity to pain, making perioperative relief with opioids alone difficult, to impossible. Although this is suggested to occur with daily doses of >100 MED there is no actual documented lower limit, and it may depend on individual variation (Mao).
2. Decreased immunity with the potential for increased infection and poorer surgical outcomes.
3. Possibly decreased motivation causing less effective preoperative conditioning and postoperative rehabilitation (Ciccone).
4. Addiction and/or diversion: To assess this, urine toxicology screen must be done preoperatively (Hser).

Weaning down or off the opioids, prior to surgery, unless on extremely high doses of opioids, or in conjunction with dangerous comorbidities such as obesity, sleep apnea, or concomitant dangerous medications such as benzodiazepines may be difficult. Consultation with a pain management or chemical dependency specialist should be considered (Gourlay).

Urine Toxicology Screen

Illegal Substances Found in Urine

Cocaine, heroin, non-prescribed opioids, benzodiazepines, amphetamines or other substances. If testing is done with point of care urine Elisa testing in the clinic, and the patient denies the positive result, it may be a false positive. Do not accuse the patient of lying.

Send the patients urine to a reference lab to utilize non-Elisa based technology including Gas Chromatography “GC”, Liquid Chromatography “LC”. The use of a mass spectrometer will add to the specimen sensitivity. For greatest sensitivity (i.e. to detect the lowest level possible, or lowest “cutoff”), some laboratories have the capacity to perform dual or “tandem” mass spectrometry (e.g.LC/MS/MS).

If a positive result is confirmed, or admitted by the patient, strongly consider a chemical dependency consult and drug rehabilitation before surgery

No scheduled substances declared as being taken are found in the urine.

Question the patient, a false negative may have occurred in which case a reference laboratory should be used for confirmation. Do not accuse the patient of diversion. This could be complicated by the patient if actively diverting or taking some of their medications before the second sample was taken. A more pragmatic approach may be, after confirmation of the negative result, to congratulate the patient on getting off all or some of their opioids prior to surgery as their urine sample had demonstrated and consider maintaining them off these drugs in the perioperative period.

THC in the Urine

Whilst the evidence for chronic pain management is present in the literature, there is always concern about addiction problems. Daily use of THC will create a positive urine sample for weeks after cessation. Occasional use will create a THC free urine within a week.

Because of the unknown effects of THC on surgery, and recovery, consider:

1. A chemical dependency consult. They may not need to see a chemical dependency specialist but there may be an underlying addiction concern.
2. Cessation before surgery with the urine being clear before surgery.

Benzodiazepines/Sedative-Hypnotics

Anti-anxiety medications are of concern prior to surgery because anxiety is the major driver of chronic pain (Griffiths). The medications are effective but unless other behavioral interventions are instituted, it will be difficult to discontinue them safely and painlessly (Pohl)

Has their use been defined and addressed prior to recommending surgery?

1. In combination with opioids, danger of overdose
2. Habituating – tolerance and dependence
3. Potential for withdrawal – rarely seizures, depression, significant anxiety, insomnia, - need to taper and/or detoxify.

Are other behavioral interventions in place?

1. Rx anxiety – CBT training, mindfulness,
2. Rx insomnia – CBT/ sleep hygiene
    a. Must be effectively treated

Meds Considered:

Benzodiazepines:

1. Alprazolam (Xanax)
2. Lorazepam (Ativan)
3. Triazolam (Halcion)
4. Clonazepam (Klonopin)
5. Diazepam (Valium)
6. Chlordiazepoxide (Librium)
7. Temazepam (Restoril)

Benzodiazepine Analogs:

1. Zolpidem (Ambien)
2. Zaleplon (Sonata)
3. Eszopiclone (Lunesta)

Other Sedative-Hypnotics:

1. Carisoprodol (Soma)
2. Chloral hydrate (Noctec)
3. Dichloralphenazone (Midrin)

Barbiturates:

1. Butalbital (Fiorinal, Fioricet)
2. Phenobarbital

Benzodiazepines, sleep medications and carisoprodol – potentiate the effects of endogenous GABA – (inhibits opening of the chloride channel) the main inhibitory neurotransmitter in the brain.

Clinically prescribed as:

1. Anxiolytic
2. Amnestic
3. Sedative-hypnotic
4. Muscle relaxant
5. Anticonvulsant – acute seizure
6. Procedural sedation
7. Management of detox (from EtOH, others)

Used to treat:

1. Generalized anxiety disorder
2. PTSD
3. Panic +/- agoraphobia

Negative Effects:

1. Drowsiness, lethargy, fatigue
2. Impaired concentration
3. Reduced ability to think and learn
4. Emotional anesthesia
5. Depression
6. Clumsiness, ataxia

7. Mood swings
8. Vertigo
9. Light-headedness

With tolerance:

1. Visuo-spatial, verbal learning and speed of processing all impaired.

Chronic use in combination with opioids – "downhill spiral hypothesis" (Ciccone).

Non-Habituating Substitutions

1. Antidepressants –
    a. Tricyclics for sleep – amitriptyline (Elavil) or nortriptyline (Pamelor), SSRI's for anxiety – e.g. escitalopram (Lexapro), sertraline (Zoloft), mirtazapine (Remeron).
    b. SNRI's for pain and anxiety – duloxetine (Cymbalta), venlafaxine (Effexor)
2. Non-benzo anxiolytics
    a. Buspirone (Buspar).
    b. Hydroxyzine (Atarax) (can also be helpful for sleep)
    c. Quetiapine (Seroquel), risperidone (Risperdal) and other "major tranquilizers".

Anti-Inflammatories

NSAID are used to suppress inflammatory processes. They act by inhibiting the action of cyclooxygenase in the arachidonic acid metabolism. The main purpose of this inhibition is to stop the synthesis of the prostaglandins which have been shown to have an effect on pain. COX have two isoenzymes, namely COX1 and COX2. To have an anti-inflammatory affect COX2, which synthesizes PGE2, must be inhibited. Prostaglandins synthesized by COX1, on the other hand, have important roles in the gastrointestinal system and in regulating the platelet aggregation.

When classified according to their mechanism of action, NSAIDs can be grouped into COX-2 selective and nonselective ones. NSAIDs, along with their anti-inflammatory activity, have analgesic and antipyretic activity. Although the mechanism of action of the analgesic effect is not yet fully explained, it is seen with lower doses compared to the anti-inflammatory activity. NSAIDs are usually metabolized in the liver into an inactive form and excreted through the kidneys.

Side Effects

NSAIDs can have gastro-intestinal side effects. These are most commonly due to COX-1 inhibition which results in a decrease in bicarbonate and mucous production in the stomach, mucosal proliferation and an increase in gastric acid secretion. These result in upper gastrointestinal system mucosal problems. Furthermore, through their transient effect on platelet aggregation, NSAIDs may cause GI bleeds. It is estimated that the rate of GI ulceration, bleeding and perforation is 1-2% and 2-5% with a 3 month long use and 1 year-long use, respectively (Gabriel, Patino)

15% patients on NSAIDs may develop liver damage. While long term use of NSAIDs is discouraged, such patients must be followed. With their discontinuation, recovery is possible.

Due to the inhibition of positive effects of prostaglandins on the kidneys, use of NSAIDs in patients with abnormal renal function is not recommended.

Idiosyncratic hypersensitivity reactions may be seen which warrants further care in atopic patients.

Conservative Treatment

NSAIDs are the second most commonly used drugs in spinal complaints. There are many studies in the literature about their efficacy. In a meta-analysis investigating spinal pain in patients without acute radiculopathy (Machado), NSAIDs were found to be statistically more effective than placebo in managing pain in the acute and short term with a moderate quality evidence. According to the results of this study the NNT to achieve a clinically significant effect of NSAIDs over placebo on pain reduction in the immediate-term was 5 (95% CI 4 to 6) and 6 (95% CI 4 to 10) in the short-term. However, NSAIDs were not found to be superior compared to the placebo in physical and mental components of the patient. In this study, average time of NSAID use was 7(5-7) days. In patients without inflammatory diseases, NSAIDs are recommended to be used for a maximum of 14 days. Wong et al. in their literature review stated that NSAIDs are more effective in persistent low back pain compared to placebo and acetaminophen.

Different oral NSAIDs lead to similar outcomes for neck and low backpain with or without radiculopathy (Wong). Because combined treatment is more successful compared to single use NSAIDs in treating spinal pain, combined treatment protocols are recommended. (Kurd). In chronic pain, NSAID use is reported to be >3 months. Ho et al. Had found in a meta-analysis that GI and cardiovascular side effects require attention in chronic NSAID use. For patients with GI problems or patients with cardiovascular problems without GI problems, COX-2 selective NSAIDs are suggested whereas for the rest of the patients nonselective NSAIDs can be used.

Perioperative Period

Controversy surrounds the use of NSAIDs in the perioperative period due to concerns regarding the negative effect on union. In the literature, the use of NSAIDs have been shown to decrease the use of opioids in a statistically significant amount (Aubrun, Chang). The effect of NSAIDs on fusion after spinal surgery has been shown to be dependent on the dose and total amount.(Sigvagnesan). Li et al. İn their meta-analysis showed that while the use of NSAIDs for less than 14 days have no negative effects on fusion in normal doses, in high doses the risk of pseudarthrosis increases (Li). Normal-dose was defined as ketorolac at a dose of less than 120 mg/day, diclofenac sodium at a dose of 25 to 300 mg in all or 75 to 150 mg/day for 2 days, celecoxib at a dose of 200 to 600 mg/day, or rofecoxib at a dose of 50 mg/day; high-dose was considered as ketorolac at a dose of more than 120 mg/d or diclofenac sodium at a dose of more than 300 mg in all. On the other hand, Deguchi, suggested that the fusion rate was lower in the patients who continued to take NSAIDs for the first 3 months after surgery than in those who did not.

ETOH

Alcohol and Orthopedic Surgical Evaluation

It is well known that smoking can increase back pain and it is understood that smoking, due to the restriction of blood flow in areas including the surgical site, can retard healing but what can be said about the risks of alcohol intake in a surgical patient and what can be considered high risk alcohol behavior in these patients?

In a study of 8.3 million patients who underwent total knee or hip replacement surgery, more than 50,000 were considered to be dependent on alcohol (Burrow). In looking further and comparing those that were considered to be alcohol dependent versus those who did not misuse, the group with dependence was 9 times more likely to leave the hospital against medical advice, 9 times more likely to have a longer hospital stay, a higher rate of complications (33% v 22%), 23 % more likely to require a blood transfusion and 15 times more likely to develop a postoperative infection.

Given this, a set of statistics that can be seen as similar in several studies, what is the option that is available to surgeons in an effort to prepare a potential surgical patient for the best outcome?

Snowden and others (Snowden) looked at heavy alcohol consumption and the increased risk of postoperative complications and did a feasibility study that was followed by a two-arm RCT looking at the effect of brief behavioral intervention versus treatment as usual. The brief behavioral intervention involved two sessions that included behavior change, goal setting and problem solving combined with identifying sources of social support as opposed to treatment as usual. The initial finding was that brief behavioral intervention does appear to offer some improvement.

In the United States, we are mandated to consider the CAGE questions when one is concerned that there might be a pattern of increased alcohol intake, self-medication with alcohol or abuse/dependence. We may be able to offer some behavior intervention if there is a psychologist within your group or available within the community. But the question becomes, what can the average surgeon and surgical practice implement that will allow them an opportunity to intervene and develop a plan that will positively affect the outcome.

The key may be to identify the patient early in the evaluation and to present some simple but clear messaging about the higher risks associated with higher alcohol use. Patients who identify high-risk behavior may respond to education when they understand that the risks of this continued behavior can result in a poor outcome or a higher need for subsequent surgery.

Fleming and Lock have shown that even a modest decrease in alcohol consumption can be possible in these patients over a long term. Patients may be amenable to reducing intake by 70 g per week (approximately 2.5 ounces or 2-3 drinks per week). This modest reduction and education may be accomplished in 1-2 sessions with a psychologist or even with a brief program developed under the guidance of a psychologist and provided by office staff who have been trained. Following are excerpts from the Snowden Paper.

Goal Set (verbatim)

Motivational Goals

1. Health, does not want to gain weight as will not be as active, better recovery time and save money.
2. Weight, save money, feel better in the morning.
3. Healthy weight and for surgery.
4. Weight management and healthy lifestyle.
5. More money better outcome to reduce the risk of any complications in surgery and to reduce recovery time.

Volitional Goals

1. Swap non-alcoholic drinks for usual drinks and leave environment for drinking (match day/pool nights).
2. Reduce drinking, at home and to start from today.
3. Reduce drinking from now and to try and stop drinking altogether.
4. Stop drinking for 2 days a week and to reduce intake by a third.
5. To reduce from seven pints per day to four by the surgery day.
6. To reduce intake to 10 units 1 week for surgery.
7. Try and reduce alcohol intake.
8. Reduce alcohol intake.
9. Reduce number of units of alcohol.
10. To still have a reduced intake of alcohol.

Other

1. Patient will see how it goes after intervention session.
2. The message for surgeons is that there are patients who abuse or are dependent on alcohol and who may or may not be willing to share that information with you at evaluation and pre-operative visits.
3. The value of recognizing that this is a significant problem and having information or resources available for patients, who are willing, to participate or educate about the risks of high alcohol intake overall and, in particular, pre surgically cannot be overstated.
4. Based on this information, it may be reasonable to give those patients additional time to participate in programs or to decrease intake (even 2-3 drinks per week) may benefit them in terms of surgical outcome and decreased risk of postoperative complications that may include additional surgery.

Other Illicit Drugs

The use of illicit/recreational drugs in the treatment/management of non-operative back pain is often tied to two etiologies—mental health and prior opioid use or addiction. The epidemic of opioid addiction is currently receiving long overdue attention and will be covered later in this chapter. However, the impact of mental health issues continues to be an issue that spinal health care providers are often not equipped to manage within the spectrum of diseases and treatments under their purview. I am curious if addiction is also considered a mental health diagnosis?

Epidemiology

The National Institute for Drug Abuse reports that “43% of people in SUD treatment for non-medical use of prescription painkillers have a diagnosis or symptoms of mental health disorders, particularly depression and anxiety”. (www.drugabuse.gov)There is a high correlation between the use of illicit drugs and the illicit use of prescription drugs and generalized anxiety disorders, panic disorders and PTSD. Additionally, there is an association

with DSM diagnoses such as borderline personality disorder, ADHD, psychotic illness and bipolar disorder. There is also an association, seen in neurosurgical circles, with a subset of those who have suffered closed head trauma.

Unemployment

Other articles suggest that unemployment may predispose an individual to see illicit drugs to offset the sense of failure, low self -esteem and distress that may accompany prolonged fiscal strain. There are some articles that document the devastating mental health effects of being on disability and becoming socially isolated. Most physicians don't know that data.

Family Dynamics

It is understood that addiction can wreak havoc within families, removing a primary source of financial support, draining savings, and driving families apart as they attempt to recreate or preserve what is left of the family unit. Family issues are a major factor in exacerbating chronic pain. (Burns) It is clear, in reviewing the literature, that spousal hostility and strained relationships help to formulate a pattern in which the use of illicit drugs or self-medication are felt to be a viable potion to dealing with the psychological, and perhaps, physical, pain that is associated with hostilities in the home.

As providers, we have an obligation to identify these individuals and families in crisis and to provide support and treatment that is, often, well beyond our capacity as health care providers for the adult spinal deformity population. This is especially true before embarking on a major deformity operation.

Mental Illness

We know, from our experiences and the literature that there is an overlap of mental illness and substance abuse and addiction and that patients with back pain often see pain medication as the solution to their problems. (Ross) Numerous studies have documented an increased risk for substance use disorders in youth with untreated ADHD. Although, some studies suggest that only those with comorbid conduct disorders have greater odds of later developing a substance use disorder.

Warning Signs of Illicit Drug Abuse

We also know that, when a patient with back pain is seen by primary care for initial evaluation and treatment, there are common patterns that emerge (Katz)

A failure to follow recommended guidelines either by the provider or patient.

1. The patient that results in an early prescription of powerful pain medications given in an effort to "treat" the pain.
2. Early referral to a spine surgeon in an effort to move the patient forward toward treatment.
3. A patient whose pain is difficult to evaluate objectively because of the overlay of depression, substance abuse, history of self-medicating and the prevalent feeling that pain medication is the only option to be considered. This group is at particularly high risk for a poor surgical outcome.

The Drugs

Cocaine

One question that providers need to ask, when considering surgical intervention, is: "Does the use of cocaine, amphetamines, heroin or other recreational drugs preclude elective deformity surgery?" The literature {Hill, Gary & Ogunnaike, Babatunde & R Johnson, E. (2006). General anesthesia for the cocaine abusing patient. Is it safe? British journal of anesthesia. 97. 654-7. 10.1093/bja/ael221} Suggests that a cocaine using patient, with a positive urine test for metabolites but remains clinically non-toxic, can undergo surgery with general anesthesia at no greater risk than a group of age and ASA matched drug-free patients. The issue remains, however, how to address the treatment of post-operative pain in the addicted or formerly addicted patient population.

A study cited on the website www.drugrehab.us indicates that even first time cocaine users showed increases in heart rate which was not as significant as the rise in blood viscosity that suggested the risk of blood clot was dramatic and could be a risk factor for heart attack in this population.

Opioids

Opioids are covered in another section of this work group. The key question is how to sort out a true addiction or can you? Does it matter?

While opioids are covered in depth in earlier sections, we would be remiss to fail to discuss the risks of physiologic v psychologic v pseudo addiction and the challenges that face the clinician who feels that the patient has real pain and requires treatment.

Weissman and Haddox discuss a case in which the patient manifests abnormal behaviors associated with inadequate pain management. The "syndrome" is one which we often see in the clinical arena and is hard to diagnose and treat: inadequate pain management followed by an escalation in the demand for medication associated with behaviors that are designed as a method of convincing the prescriber of the depth of the pain and, finally, a general mistrust of the relationship with the patient not trusting that the prescriber will respond adequately and the provider not trusting of the clinical picture that the patient presents with. This is not a new phenomenon but is one that we have little objective data available for better clinical decision making (Weissman).

When we consider the phenomenon of psychological addiction, we must also consider that the profile of these patients may include a low tolerance for pain and may also have a history of substance abuse that overlays the behavior. We know that many drugs can lead to a psychological addiction but, among those, we concern ourselves with drugs such as crystal meth, cocaine and prescription medications. There is a body of evidence that also suggests that the chronic use of marijuana may also fall into that category.

What makes a drug a risk for psychological addiction? Typically, it can be defined as a dependence on a medication and is manifest by some or all of the following:

1. Cravings

2. Issues with anxiety that occur when someone tries to stop their addictive behavior
3. Issues with depression when one is not using their drug of choice or tries to stop their addictive behavior
4. Irritability and restlessness that occur when someone is not using their drug of choice or trying to quit
5. Any other issues with mood swings that occur when one is not using their substance of choice or attempting to quit
6. Appetite loss or increased appetite associated with not using the substance of choice
7. Issues with sleep associated with quitting or not using the drug of choice
8. Issues with uncertainty about being able to stop using the substance of choice
9. Denial that one has a substance use issue or romanticizing one's substance use/abuse
10. Obsessing over obtaining or using the drug of choice
11. Cognitive issues, such as issues with concentration, memory, problem-solving, and other aspects of judgment, etc. (American addiction centers, org What is Psychological Dependence)

One can see, from a quick review of the addictive behaviors associated with perceived psychological addiction it cannot be considered entirely separate from those factors that suggest physiological addiction.

Marijuana (recreational)

With the advent of "legalized" use of marijuana for a variety of medical conditions, there has been renewed interest in using this substance for back pain. At the same time, the internet is on fire with the number of articles and sites suggesting that marijuana will cure or positively affect a variety of concerns.

Marijuana works on the chemical THC—the active ingredient. THC quickly goes to the cannabinoid receptors in the brain and sets off a chain reaction that leads to relaxation, a sense of wellbeing and a sense of enhanced perception. The effect of marijuana is related to the amount of THC in the substance.

Because of the relative ease, due to clinics and legalization, marijuana is quite prevalent in the recreational drug market. It continues to be a Schedule I substance with no approved medical use and considered for a high potential for abuse. Multiple formulations are available including THC, edibles and smokable products.

The short-term effects of marijuana or cannabinoid use include:

1. Increased heart rate
2. Low blood pressure, orthostatic hypotension
3. Muscle relaxation
4. Slowed digestion
5. Dizziness
6. Distorted perception (sights, sounds, time, touch)
7. Difficulty in thinking, memory, and problem solving
8. Loss of coordination and motor skills
9. Agitation, anxiety, confusion, panic, paranoia
10. Increased appetite
11. Dry mouth, dry eyes

Marijuana: Effects, Medical Uses and Legalization
Medically reviewed by L. Anderson, PharmD

The issue for the provider is the prevalent use in patients who are using due to prescription marijuana use and the risks that are inherent in use that can affect other treatments. There are reports of increasing heart rate for several hours after inhalation and the risks of heart attack also is 4-5 time higher than the general public—especially in the first hour after inhaling. The lungs are affected by carcinogenic hydrocarbons found in the smoke and, it is important to note, the concentrations of these and other substances may be significantly higher than that of cigarette smoke.

Because there is an effect or potential on the heart and lungs, it is important to determine the use and degree of dependence on the substance prior to establishing any treatment pattern that would increase physical activity in those with family histories of cardiac disease or stroke, high blood pressure or potential for adding additional medications to their regimen as the interactions of marijuana and other drugs can be unpredictable.

Methamphetamines

The National Institute on Drug Abuse estimates that nearly 10% of patients with chronic pain may be misusing opioids due to a theory that chronic pain and emotional stress may cause a dysregulation of brain circuitry and increase the risk of abuse.

Methamphetamine affects both the brain and the body manifesting use in a loss of interest in life. Because of the high addictive potential, many users (even first time users) find that procuring the next dose becomes paramount.

In terms of the medical implications, aside from the devastating effects of long-term use, there are higher risks for seizures, heart attacks and liver failure that can impact medical decision making. Additionally, this is a drug that has long-term implications for continued use, abuse and increasing health risks.

Ecstasy

Ecstasy is one of many "party drugs" that have taken on increased significance with the millennial age group. While considered, by many, to be an occasional recreational drug, there are users who take ecstasy on a regular basis. There are studies that show that those taking the medication may demonstrate a level of alertness that is insignificant when compared to occasional users or those who used both ecstasy and marijuana. However, while alertness does not seem to be altered, there is clear evidence for difficulty with ability to remember, problem solve, think logically or even learn. (www.drugrehab.us)

Treatment Approaches

While this is a brief summary of the problem of substance abuse and associated comorbidities and the effect that they may have on patients who have chronic pain, particularly chronic back pain, there are some options available to the provider who is faced with this problem.

It is important to recognize the potential for substance abuse or self-medicating behaviors in the initial evaluation of a patient with back pain. There are tools for assessing risk of alcohol and substance abuse that can be a helpful addition to the initial intake process. Being alert to behaviors exhibited by the patient that may suggest an underlying problem—a request for pain medication on arrival, a persistent obstructive stance toward physical therapy or other evaluation in lieu of medication, a history of depression or mental illness are a few.

One of the most prevalent issues that the provider faces when evaluating a patient with back pain who may have a tendency to addiction or abuse is a lack of education or understanding about the potential sources of back pain and treatment options. Office visits are often brief and highly structured but it may be necessary to spend time educating

the patient or having your office staff visit with the patient after their evaluation and provide them with websites, pamphlets and referrals that may help with better understanding how patients can engage in their treatment to the best of their ability.

Many practices engage a specially trained psychologist who meets with select patients to explore their concerns, evaluate their depression and coping skills and provide additional therapies to help with addiction or addictive behavior in a more productive way. We found, at one practice, that the input of the psychologist, when approached with the patient in a non-threatening and educational way, helped to establish which patients would be better candidates for surgery, which would require additional treatment and helped patients to develop better coping mechanisms that decreased the potential for substance abuse.

The challenges of meeting, assessing and participating in the treatment of patients with chronic, non-operative back pain and addiction potential or substance abuse are legion. The medical community, however, have developed recognized assessment tools, provider options and treatment programs that can be invoked to assist in caring for these patients. The key is to understand the relationship of pain to mental illness and substance abuse, be alert to the signals that the patient sends and prepare an algorithm for working with these patients that includes education, therapy, referrals and directness.

Medical Optimization

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Cardiac

Pre-operative evaluation begins with risk and functional assessment. Several "clinical calculators" exist to assess such a risk. One of the most widely used "calculator" is the revised cardiac risk index (RCRI). This simple to use "calculator" gives a point for each given condition, and based on the total number of points, a risk is assigned. Functional assessment is based on the number of metabolic equivalents (METs) a patient can perform. If from the clinical history it is not clear the number of METs the patient can perform, a modified Bruce Protocol treadmill test is requested. If the RCRI is 1 or less and the patient can perform 4 or more METS, no further testing is needed; otherwise, appropriate testing should be undertaken.

Pre-operative cardiac testing includes EKG, cardiac echo and stress testing. Typically, an EKG is not needed for low risk procedures; however, in the case of ASD it is mandated. Additionally, it is indicated in those with signs and symptoms of cardiovascular disease, an RCRI less than 1 and/or METs less than 4, those with coronary artery disease, as well as other cardiovascular history such as arrhythmias and peripheral vascular disease. A cardiac echo is typically not obtained, even in a patient with a stable left ventricular dysfunction and an ejection fraction of 37% if an echo was done within the last six months. Those with an abnormal EKG without previous work-up, possible valvular disease, as well as those with dyspnea or decompensated heart failure, should undergo a cardiac echo. Finally, stress testing is typically indicated when determining the patient's functional capacity is difficult to do from the history alone. Besides risk and functional assessment, and preoperative testing, perioperative management of medications is important in the ASD patient.

In terms of beta-blockers, they should be continued in patients chronically on them. Otherwise, they can be started on patients with RCRI of 3 or greater. It is best to start them a week in advance, so as to have time to assess if the

patient can tolerate them. With the exception of anti-diuretics, anti-hypertensives as well as statins should be continued. Prandial doses of insulin should be held, and the basal insulin doses and adjusted. Lithium levels should be checked and if stable, it should be held along with oral hypoglycemics, levodopa/ carbidopa and estrogen. Anticoagulants including over-the-counter use of aspirin and other NSAIDs, as well as herbal medications, should stopped in 5 to 7 days prior to surgery; additionally, prior to this, discontinuing anticoagulants for dysrhythmias, valvular disease and cardiac stents, the cardiologist should be consulted regarding their management, Cardiology consultation is mandatory in cases when elective non-cardiac surgery is contra indicated.

Absolute contraindication for elective non-cardiac surgery in patients with ASD include unstable angina, ejection fraction less than 35%, myocardial infarction within the last three months, and symptomatic moderate or severe valvular disease. Additionally, surgery should be held for those with balloon angioplasty, bare metal and drug eluding cardiac stents for 14 days, one month and one year, respectively. Interestingly, those with arrhythmias do not pose a clear contraindication for elective non-cardiac surgery, as they add little risk, provided adequate cardiology back up.

In summary, pre-operative assessment of ASD patient involves risk and functional capacity assessment, appropriate testing and medications management in the peri-operative period. Also, formal cardiology consultation is mandatory in patients with absolute contraindications for elective non-cardiac surgery.

Diabetes

Diabetes Mellitus is currently an epidemic in the United States and parts of Europe and is a leading cause of death and disability in the Western world. Hemoglobin A1c (HbA1c) is hemoglobin A with glucose attached to it and the test for it measures the amount of glycated hemoglobin in the blood. It serves as an evaluation of the average amount of glucose in the blood over the previous 2-3 months. A normal level is a HbA1c below 5.7%. Pre-diabetes is HbA1c between 5.7% and 6.4% and diabetes is generally identified as a HbA1c of 6.5% or higher.

It has been postulated that the risk factors associated with surgery in diabetics is not equal, and that improved diabetic control can lessen the risk of complications with surgery. We have identified three papers in the literature that assessed the association between complications after spine surgery and increasing HbA1c levels. Walid et al. [1]evaluated 122 patients and found increasing cost associated with increasing HbA1c. Takahashi found higher rates of non-union with levels above 6.5%. A final study by Hikata found that diabetic patients who developed a surgical site infection after surgery had increased HbA1c levels at the time of reoperation for the infection compared to prior to surgery.

We have established a cutoff of 7% for our patients with diabetes mellitus prior to surgery. Any patients with elevated levels are referred back to their primary care physician or to our diabetes clinic for tighter management prior to surgery.

Renal

Chronic renal failure (CRF) is associated with hypertension and diabetes. Patients with CRF or end-stage renal disease (ESRD) are at risk for osteoporosis, electrolyte imbalances, and anemia (Halpin). Hyperkalemia is a frequent postoperative complication in patients with ESRD. Preoperative and postoperative potassium levels should be monitored. Hemoglobin levels should be checked and corrected to a normal range (Hg>10.0) before surgery

(Pinson). Underlying comorbidities associated with CRF include hypertension, diabetes, coronary artery occlusive disease, arrhythmias, iatrogenic Cushing disease, and cerebrovascular disease. Additionally, patients may have low bone mineral density, with abnormally low T-scores (Han, 2009).

Volume status should be monitored closely, and dialysis patients should have dialysis within 24 hours of the surgical procedure (Han). Calcium and phosphate levels should be maintained in the normal range. Bone density should be assessed pre-operatively and treated with vitamin D supplementation if low. (Halpin, 2010)

Best practices for preoperative preparation for patients with renal disease should include a consultation with a medical specialist to:

1. Regulate chemistries, including serum glucose, potassium, calcium, and phosphate.
2. Ensure adequate preoperative hemoglobin levels.
3. Diagnose and treat potential low bone density.
4. Coordinate appropriate dialysis and volume management.

Liver

The most common causes of advanced liver disease include viral infection, alcohol abuse, autoimmune disease, drug reaction, genetic metabolic aberrations, cholestasis, and inflammatory disease of the bile tracts. Almost every organ system in the body is at risk of secondary manifestations of advanced liver disease. Patients with chronic liver disease undergoing elective surgery are at risk for acute liver failure, which can lead to severe coagulopathy, encephalopathy, adult respiratory distress syndrome (ARDS), acute renal failure, and sepsis (Halpin).

Model for end-stage liver disease (MELD) scores have been shown to be a predictor of mortality risk in patients with liver disease. MELD scores are comprised of the international normalized ratio (INR), total bilirubin, and creatinine levels, and have a direct correlation with postoperative mortality. A MELD score less than 10 is generally considered safe, while a score greater than 20 significantly increases the risk of complications (Northup).

Childs-Pugh staging is used to classify chronic liver disease. 1 to 3 points is given for increasing pathology related to six areas: nutrition, ascites, encephalopathy, bilirubin, albumin, and prothrombin time. Scores of 6 or less are considered class A, scores from 7 to 9 are class B, and scores of 10 or more are class C. Postoperative morbidity and mortality have been shown to increase with higher Childs-Pugh scores (Wiklund).

Best practices for preoperative preparation for patients with liver disease should include a consultation with a medical specialist to:

1. Correct coagulopathies
2. Optimize renal function
3. Prevent sepsis
4. Minimize preexisting encephalopathy

Patients with more severe findings, including acute hepatitis, fulminant hepatic failure, severe chronic hepatitis, severe cirrhosis, severe coagulopathy, hypoxia, cardiomyopathy, or acute renal failure should not undergo elective surgery (Halpin).

Nutrition

Albumin and prealbumin are serum proteins that have been recognized as markers for increased risk of complications in patients undergoing surgery. While normative values vary among laboratories, typical value for albumin are 3.5-5.0 g/dl and pre-albumin are 20-36 mg/dl in adults. Schoenfeld et al[1] queried the National Quality Improvement Program (NSQIP) for patients undergoing spinal arthrodesis surgery and found 2150 patients who also had a preoperative albumin level. Their study showed that preoperative albumin levels of 3.5 g/dl or lower were associated with an increased 13.8 Odds Ratio (OR) for mortality, a 2.5 OR for wound infection and a threefold increase in complication risk.

Adogwa and colleagues published two separate studies analyzing serum albumin levels and complications and readmissions. In 2014 they studied 136 patients undergoing spine surgery and found that a serum albumin level under 3.5 g/dl was associated with a threefold increase in complications and logistic regression showed it was a significant predictor of complications with an OD of 4.21. Later in 2016, they found it was an independent predictor of readmission in 145 patients undergoing elective spine surgery (Adogwa 2014, 2016).

Tempel found that among 83 patients treated for a postoperative wound infection after spine surgery, 82 had prealbumin levels below 20 mg/dl. Bohl studied 4,310 NSQIP patients and found serum albumin less than 3.5 g/dL was an independent risk factor for infectious and wound complications, as well as 30-day readmission and increased inpatient stays. Finally, Fu queried the NSQIP database and identified an association between hypoalbuminemia and increased complications and inpatient stays in patients undergoing anterior cervical discectomy and fusion.

We currently use albumin and pre-albumin as screening tools in our clinic. Any patient being considered for surgery who has low levels of either marker is referred to our nutritionist or to their internist to work up the cause of these low levels.

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Physical Rehabilitation in Non-Operative Management of Adult Spinal Deformity

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Resources and Tools

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- Oregon Pain Management Commission's Pain Management Module, Changing The Conversation About Pain: Pain Care Is Everyone's Job, Available at: www.oregon.gov/oha/HPA/dsi-pmc/Pages/module.aspx.
- Oregon Pain Management Commission's Pain Care Toolkit (Resources to help clinician's discuss pain with their patients) Available at: www.oregon.gov/oha/HPA/dsi-pmc/Pages/pain-care-toolbox.aspx.

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