Surgical Treatment of Osteoporotic Spinal Disorders

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Vertebral compression fracture in the setting of osteoporosis is a frequently encountered clinical problem that is becoming even more prevalent with an aging population. Osteoporosis is characterized by decreased bone density, disruption of trabecular microarchitecture, and increased susceptibility to fractures. According to the World Health Organization osteoporosis is defined as diminished bone density measuring 2.5 standard deviations below the mean bone density of healthy 25-year old same sex members of the population evaluated with dual-energy x-ray absorptiometry (DEXA) [1]. Based upon this definition, an estimated 25% of postmenopausal women and 35% of women over the age of 65 in the United States suffer from osteoporosis [1]. The risk of proximal femur, distal radius, and proximal humerus fractures is significantly increased in postmenopausal women though vertebral compression fractures are the most common [2]. The incidence of osteoporotic fractures of the spine is greater than 500,000 per year in the United States with women being affected twice as often as men [3]. One fourth of women reaching menopause can expect to suffer one or more vertebral compression fractures in their lifetime [4]. In the United States, 25% of women over the age of 70 years and 50% of women over the age of 80 years have radiographic evidence of vertebral compression fractures [5].

Vertebral compression fractures can be classified into three types: wedge, biconcave, or crush [6]. Wedge fractures are the most common and the severity of the deformity seems to be directly related to the bone mineral density. Wedge type fractures cause increased kyphosis and decreased spinal column height. Biconcave or codfish fractures occur mainly in the lumbar spine and can result in loss of lordosis and decreased spinal column height. Crush fractures are associated with greater than 50% loss of height and may occur in both the thoracic and lumbar spine. These fractures may have posterior retropulsion of bone into the canal, which can lead to neurologic deficits.

The deformity associated with each of these fracture types may lead to loss of height and thoracic hyperkyphosis (dowager's hump), abdominal protuberance, and loss of lumbar lordosis. The loss of height may lead to abdominal compression resulting in loss of appetite, early satiety, and weight loss [7]. Thoracic hyperkyphosis leads to compression of the lungs resulting in decreased pulmonary function and an increased risk of pulmonary death. One thoracic vertebra fracture causes a 9% loss of forced vital capacity, which increases the risk of pneumonia and obstructive disease [8]. Neurologic involvement is not usual although not rare and late neurologic involvement can be seen up to 18 months after a fracture. Aside from these various physiology effects vertebral compression fractures also have a negative effect on the psyche with higher than average rate of depression and loss of self-esteem in addition to a deteriorating quality of life.

Lastly the overall rate of mortality is increased 5-fold compared to age-matched controls and is comparable to survival rates after hip fracture [9].

The treatment of the patient with osteoporotic compression fractures is twofold: pain management and prevention of instability or neurologic deterioration. Certainly to be complete in the workup it is important to understand the cause of the fracture. Workup is needed to determine the cause of the underlying osteoporosis to ensure that an occult malignancy is not being overlooked. Laboratory studies including a CBC, serum chemistries, ESR, SPEP, and in some cases PSA or CEA should be obtained.

Radiographic studies include plain films, CT with thin cuts as well as MRI may be obtained. MRI is quite helpful in distinguishing an acute fracture from a subacute or chronic fracture. MRI is also helpful in differentiating a benign fracture from a malignant fracture. Imaging clues to look for would be soft tissue extension, involvement of the pedicles with marrow signal changes, and noncontiguous lesions.

Pain management consists of non-narcotic analgesics, muscle relaxants for paravertebral muscle spasm, and narcotic analgesics. Typically the severe pain resolves over a period of 6-8 weeks [7]. Often times it can be difficult for elderly patients to tolerate these medications due to the side effects of confusion, constipation, increased fall risk and potential for addiction.

Bracing is the treatment of choice for most fractures. A short period of bed rest may help to relieve severe pain but is contraindicated beyond a few days [10]. Bracing is typically necessary the first 6-8 weeks or until the acute pain resolves. The type of brace is dependant on the location of the fracture. Many times the brace may be poorly tolerated due to pressure with sitting or due to body habitus it may be difficult to provide a well-fitted brace. Bracing may provide comfort with prolonged standing or car rides at a later point.

Although most patients will recover from the acute pain associated with a new vertebral compression fracture, some will not and do continue to experience chronic persistent or recurrent pain. These patients may benefit from surgical intervention. The surgical treatment of vertebral compression fractures is complicated by the deficient mechanical properties of osteoporotic bone, which may not withstand the local application of forces through structural grafts and instrumentation [11].

Surgical goals are to restore anatomy, correct deformity, and preserve function. The treatment for vertebral compression fractures ideally should address the pain associated with the fracture and the kyphotic deformity. Vertebroplasty and kyphoplasty are two techniques that address the pain but kyphoplasty also to address the deformity. These operations utilize x-ray guidance to inject polymethylmethacrylate (PMMA) into the fractured vertebral body.

Vetebroplasty was first described in 1987 [12] in Europe and in the U.S. in 1993 [13]. The pain relief brought about by vertebroplasty is probably secondary to fracture stabilization. The injected cement hardens and stabilizes micromotion at the fracture site. The indications for the procedure have evolved. Ideally the patient with unimproving pain and less than 60% compressed is a candidate. If there is more compression it becomes difficult to navigate the trocars into the vertebral body. Suggested indications include stabilization of painful osteoporotic vertebral fractures, painful vertebra as a result of osteolytic metastases or multiple myeloma, Kummel's disease, painful hemangiomas, and debilitating pain and loss of mobility that was unresponsive to

medical treatment with the pain thought to from the uninvolved vertebra. Contraindications include infection, vertebra plana, neural compression, and coagulopathy. Risks associated with the procedure include cement extravasation, ~65% [14], cement pulmonary emboli, radiculopathy, infection, bleeding, neural compromise, and mortality. Additionally a new or contiguous fracture is a relatively frequent occurrence. One study showed a 52% new fracture rate over 4 years [15].

The technique utilizes a uni or bipedicular approach although an extrapedicular approach can be performed, injecting cement under fluoroscopic guidance using a large bore needle. Clinically the procedure provides lasting partial or complete relief of pain within 72 hours. Although the procedure can be done under general anesthesia more typically it is performed with the patient under monitored anesthesia so that the patient can report symptoms of neural encroachment. Biplanar fluoroscopy can facilitate the procedure. The results show 73-97% of patients with good to excellent pain relief in up to 4 year follow –up studies.

Kyphoplasty is a similar technique that employs the use of a balloon tamp that is expanded within the vertebral body. It has several advantages: lower risk of cement extravasation, and better restoration of vertebral body height. By creating a cavity with the balloon the process of cement injection becomes safer as it is creating a low pressure cavity into which the cement will preferentially flow. It is indicated for any progressive or painful osteoporotic or osteolytic compression fracture. It is contraindicated in burst fractures, active infection, and in osteoblastic, matrix, or tissue producing solid tumors. The technique is similar to that of vertebroplasty and in addition the inflatable balloon tamp is expanded under fluoroscopic guidance until maximum fracture reduction is achieved or the balloon reaches a cortical wall. The balloon is then deflated and the cement injected. The patient is discharged usually the following day without a brace. Average correction of 47% or 14 degrees have been reported in addition to good pain relief and infrequent complications [16].

Open surgical treatment of osteoporotic vertebral compression fractures and deformity of the spine can be quite challenging in the face of osteoporotic bone. Deficient bone stock, medical comorbidities, and impaired nutritional status pose difficulties for the treating surgeon. The surgeon must be aware of several important nuances in this patient population. The bone has decreased mechanical strength and the pedicle is the strongest point of fixation. The surgeon has in his armamentarium of implants available including hooks, screws, rods, and bone augmenting devices including methylmethacrylate (cement) to facilitate fusion. There is no clear indication that osteoporosis interferes with the ability to heal bone. The surgical plan therefore, must be tailored to the individual patient with desired goals the correction of deformity, prevention of neurologic deficit, and relief of pain being tantamount.

In determining the surgical procedure that is optimal the risks of surgery need to be offset by the disease present. In other words, we don't want the cure to be worse than the problem itself. The operation can be performed from the front (anterior), back (posterior) or both.

An anterior approach is useful when a fracture has an associated neurologic deficit and spinal canal decompression in necessary. Additionally, recreation of spinal column height is best addressed from the front in the setting of kyphosis (collapse). The

disadvantages include an inability to obtain adequate bone fixation as well as graft subsidence into adjacent levels.

The posterior approach is advantageous as it provides the pedicles as the best source of fixation. Bone screws are passed through the pedicles and into the vertebral bodies. The ability of a screw to hold in the bone is described by it's pullout strength. Pullout strength is greatly compromised in osteoporotic bone. This would be analogous to the strength of screws in drywall versus the wooden stud when hanging a picture. If too much stress is applied the screw will pull right out. Therefore additional points of fixation must be applied well above and below the fracture which when connected to rods provides a strong construct and good chance for fusion. Additionally, deformity can be corrected especially when done in conjunction with an osteotomy.

Combined approaches via both the front and back allows for the advantages of the above-mentioned procedure. However the length is greatly increased as well as the potential for problems. The difficulty in healing two incisions especially in the elderly must be considered. Risks increase which potentially may result in mortality.

Certainly early management of osteoporosis by prevention affords the least morbidity possible. However with a continually aging population and increasing incidence of vertebral compression fractures surgical reconstruction of the spine will be of significant interest. The development of new procedures such as vertebroplasty and kyphoplasty offer advancement in the field and newer techniques for open treatment will continue to evolve.

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