7

Percutaneous Vertebroplasty: Procedure Technique

John M. Mathis

This chapter presents the general technique used to perform a percutaneous vertebroplasty (PV) and presumes that the reader has appropriate knowledge of issues discussed in earlier chapters such as pertinent spinal anatomy, patient selection and evaluation, biomechanics of PV, and bone cement selection. If more information about these subjects is needed, see the preceding chapters.

Informed Consent

Written permission for the procedure is recommended following a complete discussion of the risks and complications of the procedure with the patients and/or their representatives. Now that Food and Drug Administration (FDA)—approved bone cement for percutaneous vertebroplasty and balloon kyphoplasty (KP) is available (Spineplex, Stryker-Howmedica, Kalamazoo, MI), there is no good reason to use nonapproved cements except as part of an investigational review board (IRB)—approved investigation (with an FDA-approved device exemption). The discussion of risks and complications should include potential side effects that are known to be possible with these procedures. These include bleeding and infection (both rare), temporary pain exacerbation, cement leaks (resulting in neural or pulmonary compromise), and death (which has been reported due to severe cement allergy or pulmonary compromise).

There are clinical and anatomic situations that help the operator categorize a patient's risk as low or high. Examples of low-risk patients are those with no known comorbidities and who have simple anatomic fractures (such as a mild, single-level fracture in the low thoracic or lumbar region). High-risk patients have complex anatomic situations such as a vertebra partially destroyed by a tumor or a tumor extending into the epidural space. In these situations, neural compression, due to cement leak or additional extrusion of tumor, make clinical complications more likely. Other high-risk situations would include patients with preexisting pulmonary compromise. These patients may have

otherwise simple fractures that still can pose a significant risk as small amounts of marrow fat or cement embolized to the lungs may produce respiratory failure. Remember, all PV and KP procedures result in hydraulic displacement of marrow elements that end up in the lung (even without cement emboli). In severe chronic obstructive pulmonary disease (COPD) this can result in substantial pulmonary compromise, respiratory failure, and even death.

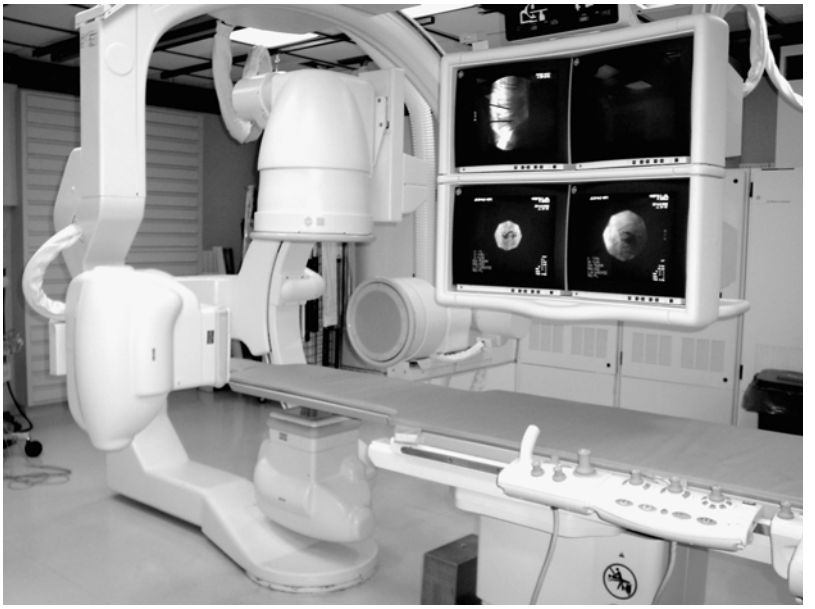
Patients in the high-risk category should be informed of this situation during consent discussions. Even when the expected risk is low, potentially severe complications should be discussed and understood.

Image Guidance

Since the first PV procedure (1), fluoroscopy has been the preferred method of image guidance for performing PV, although computed tomography (CT) has infrequently been used as a primary or adjunctive tool (2,3). Because this procedure was initiated and popularized by interventional neuroradiologists, biplane fluoroscopic equipment was commonly available and often used (Figure 7.1A). This equipment allows multiplanar, real-time visualization for cannula introduction and cement injection and permits rapid alternation between imaging planes without complex equipment moves or projection realignment. However, this type of radiographic equipment is expensive and not as commonly available in interventional suites or operating rooms unless they are used for neurointerventional procedures.

It takes longer to acquire two-plane guidance and monitoring information with a single-plane than with a biplane system. However, it is feasible and safe to use a single-plane fluoroscopic system as long as the operating physician recognizes the necessity of orthogonal projection visualization during the PV (or KP) to ensure a safe procedure. With a single-plane system for PV, the C arm moves will mean a slower procedure compared with biplane. A temporary biplane configuration can be made using two mobile C arms together (or a mobile C arm with a fixed plane angiographic instillation) (Figure 7.1B). Set-up time is longer, but the resulting biplane configuration will result in a more rapid procedure with less attention by the operator to continually move the imaging plane to obtain pictures in multiple projections.

Gangi et al. (3) introduced the concept of using a combination of CT and fluoroscopy for PV. This method gained a brief period of popularity in the United States when the study by Barr et al. (2) was published. They subsequently abandoned CT for routine PV. Although the contrast resolution with CT is superior to that with fluoroscopy, the CT method does not include the ability to monitor needle placement and cement injection in real time. This may be acceptable for needle placement, particularly if a small-gauge guide needle is first placed to ensure accurate and safe location before introducing a large-bore, trocar–cannula system. However, it is certainly not optimum for monitoring the injection of cement. For this reason, Gangi et al. (3) and Barr et al. (2) used fluoroscopy in the CT suite during cement introduction



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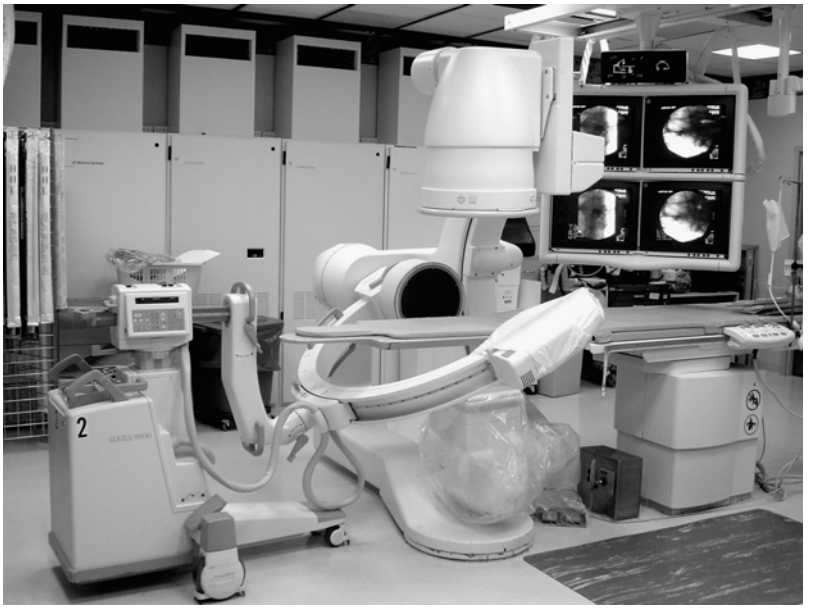

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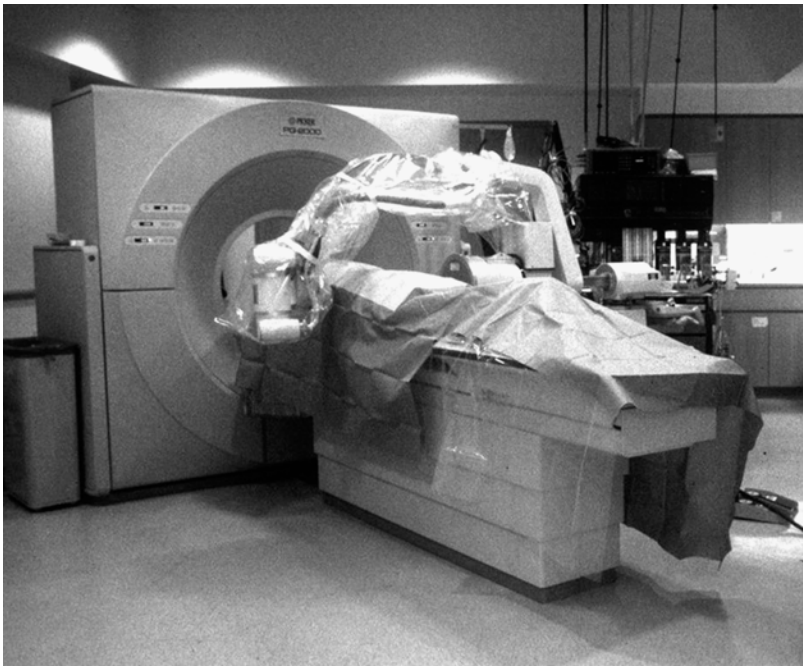
Figure 7.1. **(A)** Typical biplane configuration with independent imaging planes capable of producing images in two projections without complex equipment movements. **(B)** This shows a temporary biplane arrangement with a mobile C arm moved into position along with a fixed single-plane fluoroscopic system. Although not necessary routinely, this type of configuration may be advantageous when starting PV or KP to make the imaging acquisitions faster. **(C)** Combined CT and mobile fluoroscopy setup. In this arrangement, fluoroscopy may be constrained to lateral images only based on the size and configuration of the CT table. (A, from J.M. Mathis [ed], Image-Guided Spine Interventions. New York: Springer, 2004, with permission.)



C

Figure 7.1. *Continued*

(Figure 7.1C). Computed tomography does not afford one the opportunity to watch the cement as it is being injected or to alter the injection volume in real time if a leak occurs. Also, unless a large section is scanned with each observation, it is possible to have leaks outside the scan plane that may be missed by looking only locally in the middle of the injected body. Barr et al. (2) used general anesthesia with their CT-guided cases because of the need to minimize patient motion. This was successful but added a small additional risk to the procedure and considerable complexity and cost. For all of these reasons, CT has not found a primary role in image guidance for PV; it is reserved for extremely difficult cases.

Examples of situations where CT is preferred over fluoroscopy include the treatment of cervical or high thoracic vertebra (where the approach is anterior and fluoroscopy is inadequate to see critical structures such as carotid or vertebral arteries), destroyed vertebra where there is a risk of tumor displacement into the spinal canal during cement introduction, and in the treatment of sacral insufficiency fractures. Here one must modify the cement injection technique. Computed tomography scans are made frequently after injections of small aliquots of cement. In this situation, cement leaks should be detected before they are large and clinical symptoms avoided (Figure 7.2). These techniques are discussed more fully in Chapter 11.

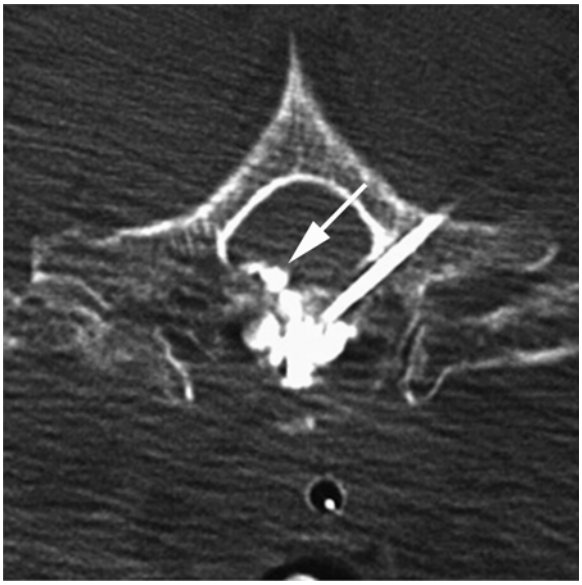


Figure 7.2. A CT image taken during PV showing cement filling of a T1 vertebra (invaded by tumor) with a small (asymptomatic) cement leak into the spinal canal (white arrow). Cement injection was terminated, and the patient had a good result from the PV.

Laboratory Evaluations

Coagulation test results should be normal, and the patient should not be taking coumadin. Coumadin may be discontinued and replaced with enoxaparin sodium (Lovenox, Rhône-Poulenc Rorer Pharmaceuticals, Inc, Collegeville, PA), taken once or twice a day on an outpatient basis. Coumadin may also be stopped and replaced with heparin, but this medication must be administered intravenously, requiring hospital admission. Both enoxaparin sodium and heparin can be reversed with protamine sulfate before PV and restarted postprocedure. Aspirin use is not a contraindication to the procedure.

Percutaneous vertebroplasty is not recommended for patients with signs of active infection, but elevated white blood cell counts clearly associated with medical conditions such as myeloma or secondary to steroid use are not contraindications.

Antibiotics

For PV, as for other surgical procedures that implant devices into the body, intravenous antibiotics are routinely given, usually 30 minutes before starting the procedure. The most common antibiotic used in this application is cephazolin (1 g) (4). If an alternative must be used because of allergy, ciprofloxacin (500 mg orally, two times daily) may be substituted and continued for 24 hours after the completion of the

procedure. Optimally, an oral antibiotic should be started 12 hours before a PV procedure.

Antibiotics are added to the cement only in the situation of immunocompromise. This is due to the very low risk of infection after PV with only minimal evidence that any benefit occurs from antibiotics in the cement (and then only in the situation of immunocompromise). Additionally, there is a mechanical change in the cement that is produced by the addition of the antibiotic. This should be avoided unless definitely necessary.

Anesthesia

During PV, it is common to use both local anesthetics and conscious sedation to make the patient comfortable and relaxed. Patients who request not to receive intravenous (IV) sedation or who cannot have it for safety reasons still can be treated with only mild discomfort if appropriate attention is given to local anesthetic placement. To reduce the sting and discomfort associated with locally administered anesthetics (lidocaine, etc.), one may buffer the anesthetic by the addition of a mixture of 1 mL of bicarbonate to 9 mL of lidocaine. This mixture reduces, but does not eliminate, the anesthetic sting. I commonly use a lidocaine mixture that contains both bicarbonate and Ringer's lactate, and this essentially eliminates the sting of the local anesthetic. At my institution, this mixture is prepared on a daily basis for all procedures requiring local anesthetics. The excess is discarded at the end of each day. This preparation has a low concentration of lidocaine (0.5%) and allows the use of a more generous volume locally with less risk of toxicity (Table 7.1).

Whatever the chosen local anesthetic preparation, the skin, subcutaneous tissues along the expected needle tract, and periosteum of the bone at the bone entry site must be thoroughly infiltrated. Once this is accomplished, the patient will experience only mild discomfort while the bone needle is being placed, regardless of whether conscious sedation is used. Local anesthesia alone may be insufficient if a mallet is used for needle introduction. In this case, IV procedural sedation is required for patient comfort.

Intravenous procedural sedation has become a common adjunctive method for pain and anxiety control in awake patients who undergo minimally invasive procedures. I use a combination of IV midazolam

Table 7.1. Modified Local Anesthetic Solutions.

Solution	Lidocaine (4%)	Lactated Ringer's	Bicarbonate	Epinephrine
1	4 mL	24 mL	2 mL	0
2	4 mL	24 mL	2 mL	0.15 mL (1:1,000)

Solution 1 makes a "sting-free" local anesthetic with 0.5% lidocaine. Solution 2 is "sting free" with 0.5% lidocaine and 1:200,000 epinephrine. These should be mixed daily and discarded at the end of the day. The total volume of each mix is 30 mL.

(Versed, Roche, Manati, PR) and fentanyl (Sublimase, Abbott Labs, Chicago). To decrease anxiety and diminish the discomfort associated with positioning, it may be helpful to begin these medications before placing the patient on the operative table. Dosages are chosen according to patient size and medical condition. The final amount is determined with titration while observing the patient's response.

General anesthesia is rarely needed for PV, but it is used occasionally for patients in extreme pain who cannot tolerate the prone position used in PV or for patients with psychological disability that would preclude a conscious procedure. It is not needed for routine PV (or KP) and should be avoided when possible because it adds a small additional risk and considerable cost to the procedure. As described previously, Barr et al. (2) used general anesthesia routinely with CT-guided procedures to ensure minimum patient motion.

Needle Introduction and Placement

The original choice of a device for percutaneous cement introduction was based on device availability. The size of these devices was empirically chosen to allow the viscous polymethylmethacrylate (PMMA) cement to be injected. Originally 10- to 11-gauge trocar–cannula systems were used. Needle systems have now been specifically developed for cement introduction into collapsed vertebra (Figure 7.3A). It is becoming progressively common to see smaller gauge needles used routinely (13–15 gauge). All will work with the least resistance during injection found with the larger bore systems. The smaller systems are necessary in small pedicles or in the cervical spine. A 13-gauge cannula can be placed through any adult pedicle from the thoracic through lumbar spine without fear of it being too large. (I now use 13-gauge systems for all levels and have stopped stocking 11-gauge devices for routine use.) Regardless of size, the diamond tip configuration (Figure 7.3B) offers the maximal ease of needle introduction into bone. Bevel tip needles have been described as useful for changing the tip direction according to which way the bevel is oriented. This is certainly true with small needles (i.e., 21–25 gauges), but I doubt that 13-gauge and larger needles are significantly directable by soft, osteoporotic bone. The bevel tip is certainly harder to introduce into bone as it tends to slip off any surface that is not flat.

Bone biopsy can be accomplished easily with the trocar removed (Figure 7.3C). This does require removing the cannula to get the biopsy specimen out. Biopsy devices are made that fit both the 13- and 11-gauge systems (Figure 7.3D) and allow biopsy and subsequent PV without removing the cannula.

Several introductory routes for needle delivery are possible, including (1) transpedicular, (2) parapedicular (transcostovertebral), (3) posterolateral (lumbar only), and (4) anterolateral (cervical or high thoracic). These are discussed in detail in Chapter 2. The classic route for most PV procedures is transpedicular (Figure 7.4); see also Figure 2.8A. It offers the following advantages:

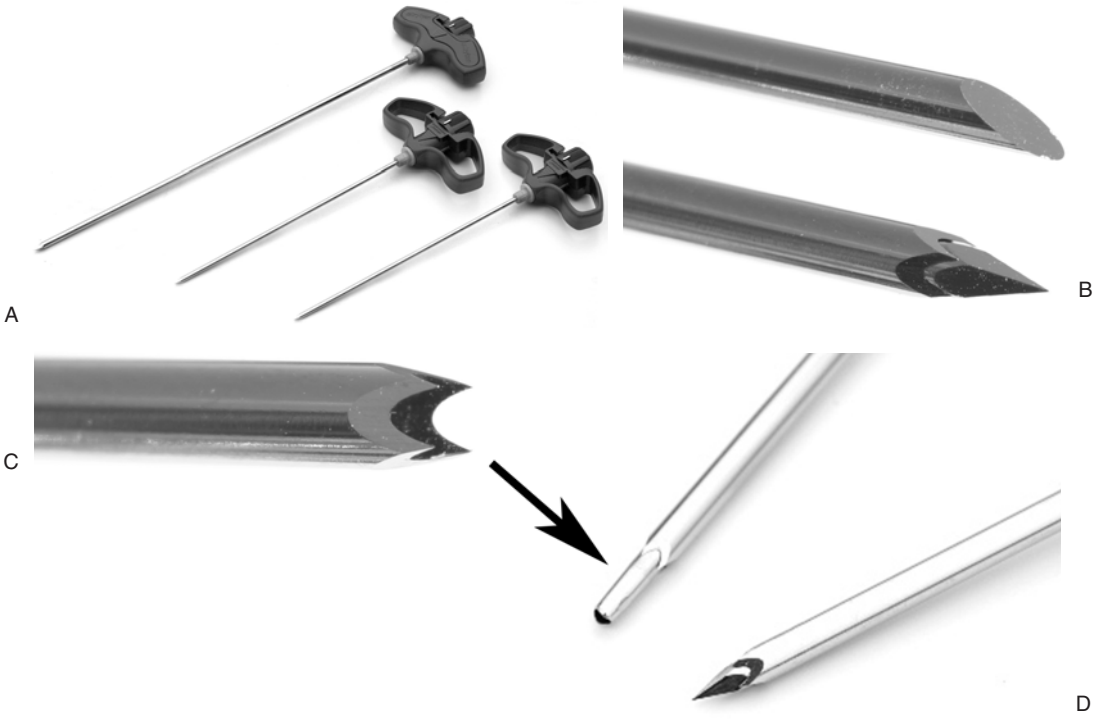


Figure 7.3. (A) Needle systems for PV developed by Stryker Medical Instruments for cement delivery. These needles have a fixed handle for ease of introduction into bone. They are made in various lengths and sizes, with 13 and 11 gauge being most common. **(B)** Close-up views of the needle points showing a match-ground diamond point with a very sharp tip that engages the bone surface to prevent slipping during the start of needle placement. The flat facets of the point cut bone with a back and forth motion of the hand during needle introduction. **(C)** Close-up view of the Stryker cannula with the trocar removed. This can be used to obtain a bone biopsy specimen but will require removal to retrieve the specimen. **(D)** Close-up view of the Stryker biopsy device (black arrow) inserted through the cannula. This allows a biopsy specimen to be extracted through the cannula. The trocar is then reinserted and the trocar–cannula placed in final position for PV. (Courtesy of Stryker Medical Instruments, Kalamazoo, MI.)

- It provides the operating physician with a definite anatomic landmark for needle targeting.
- It is very effective for PV and for biopsy of lesions inside the vertebral body.
- It is inherently safe, with no other adjacent anatomic structures that might be damaged with the needle (e.g., nerve root, lung) as long as an intrapedicular location is maintained.
- It provides a safe entry point that allows easy compression of overlying soft tissues, postprocedure, to minimize bleeding.

In the upper thoracic region and in small patients, the size of the pedicle may be too narrow for an 11-gauge needle. In this situation, a 13-gauge needle should be used.

The parapedicular or transcostovertebral approach (Figure 7.5; see also Figure 2.8B,C) was devised to allow access when the transpedicular route is not desirable or possible (e.g., small pedicle). As the needle

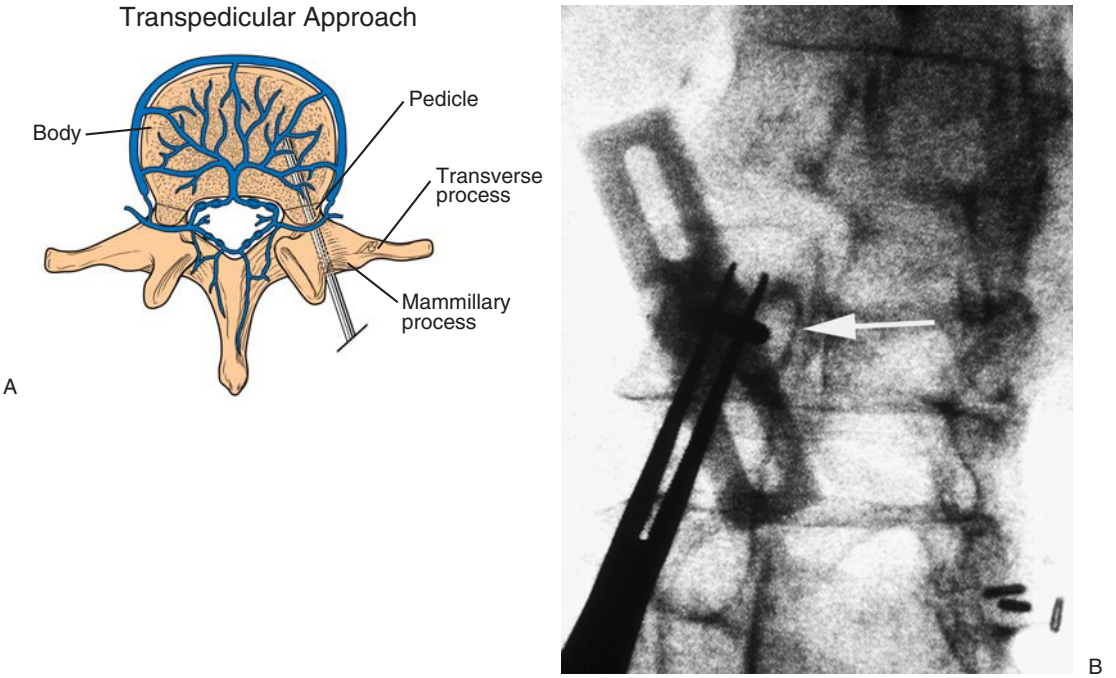


Figure 7.4. (A) Drawing of the transpedicular approach with a needle traversing the pedicle. The pedicle provides a bone channel that allows access from the skin surface to the vertebral body and that bypasses critical areas like the spinal canal. **(B)** Oblique fluoroscopic image of a needle being introduced via the transpedicular approach. The pedicle (white arrow) is seen as an oval target through which the needle can be safely placed.

passes along the lateral aspect of the pedicle, rather than through it, a small pedicle does not preclude using an 11-gauge needle for cement introduction. Also, this approach angles the needle tip more toward the center of the vertebral body than does the transpedicular approach. At least in theory, this angle may allow easier filling of the vertebra with a single injection (this may not be the case if an early cement leak occurs). A parapedicular approach has a higher chance of creating a pneumothorax than does the transpedicular route. A second potential problem with the parapedicular route is that the needle enters the body only through its lateral wall. This approach may increase the risk of paraspinous hematoma after needle removal. Because the osteotomy site occurs laterally along the side of the vertebra with a parapedicular approach, one cannot apply local pressure after needle removal as can be done with the transpedicular route.

In the cervical spine, a transpedicular route is very difficult, so an anterolateral approach may be used as an alternative. Needle introduction must avoid the carotid–jugular complex, the vertebral artery, and the esophagus. To accomplish this, the operating physician (as in

cervical discography) can select a right-sided approach (opposite the esophagus) and manually push the carotid out of the path of the needle (Figure 7.6; see also Figure 2.3). Alternatively, CT can be used to visualize the carotid, and a safe trajectory that will miss the vascular structures can then be chosen. A small guide needle can be inserted to ensure accurate placement outside the carotid complex. I prefer the guide needle alternative because it gives positive guidance and confirmation without excessive fluoroscopy to my hands during needle introduction. However, because osteoporotic fractures in this area are rare, the cervical spine only occasionally undergoes PV. Neoplastic disease usually produces the uncommon need for PV intervention in the cervical spine (additional information on this approach can be found in the case series on "cervical approach"; see Case 6 in Section II).

Once the needle route is chosen, IV procedural sedation and local anesthesia are administered. A small dermatotomy incision is made with a No. 11 scalpel blade. The trocar and cannula system are introduced through the skin incision and subcutaneous tissue to the periosteum of the bone. This introduction can be facilitated with a sterile clamp to guide the needle during fluoroscopy (Figure 7.7), thus avoiding radiation to the operating physician's hands. In osteoporotic bone, penetrating the bone cortex and advancing the needle into the body is usually very easy. In a patient with neoplastic disease, the bone may still be very dense and strong (except where it has been destroyed by a tumor), and, in this situation, the use of a mallet to advance the needle is a technique clearly superior to that of manual advancement.

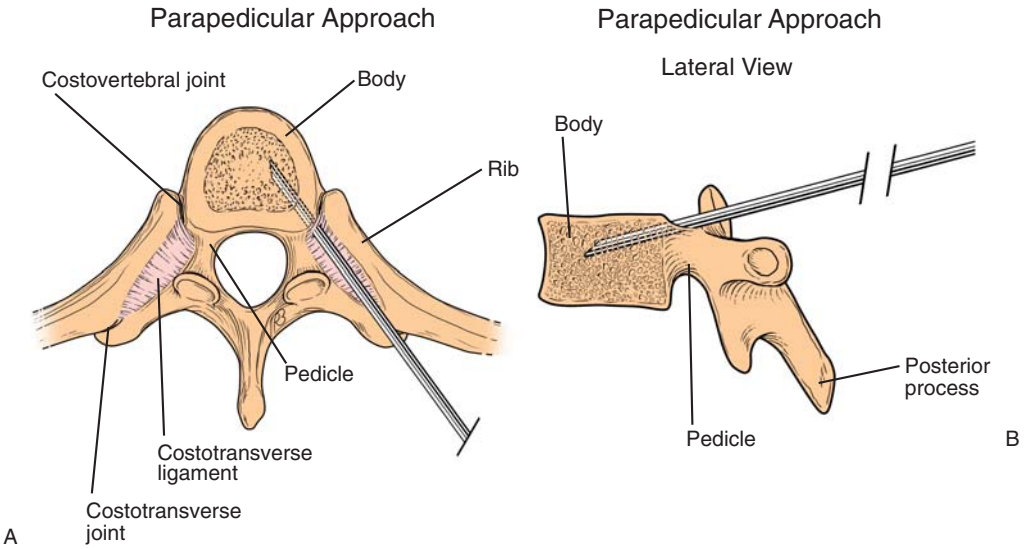


Figure 7.5. (A,B) Drawings that show needle position for a parapedicular approach from two views. The needle position is lateral to the pedicle and approaches the vertebra from above the transverse process. This avoids the exiting nerve root that courses under the pedicle. The needle entry site is along the lateral aspect of the vertebra. This location does not allow access for local pressure after needle removal, making the chance for bleeding higher than with the transpedicular approach.

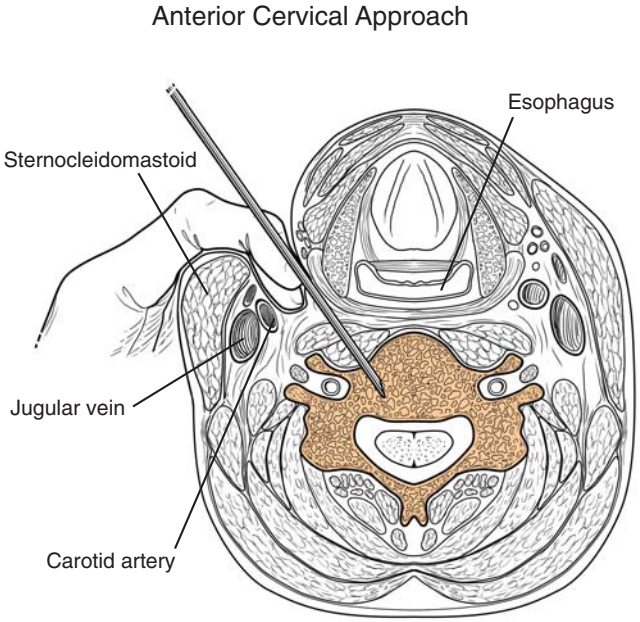


Figure 7.6. Drawing showing manual displacement of the carotid–jugular complex and guide needle insertion. This allows access to the vertebra and spares injury to the neck vessels. Needle position can be confirmed with CT.

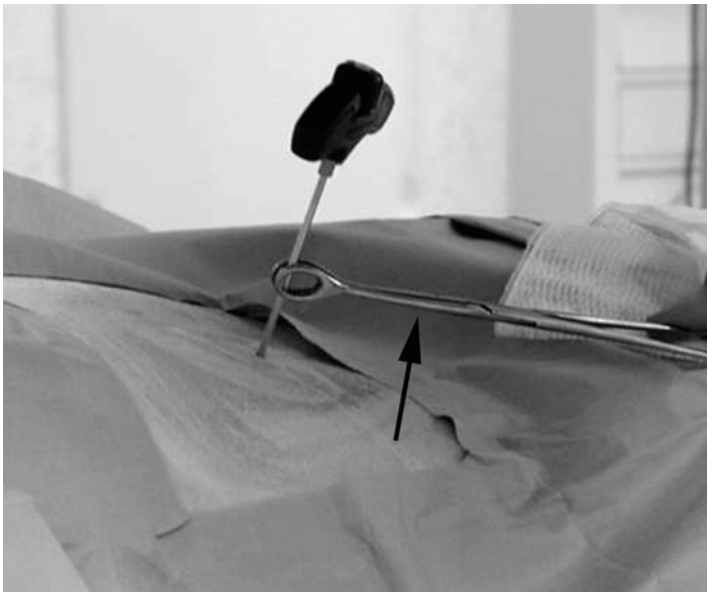


Figure 7.7. This picture shows a long clamp (black arrow) used to hold and position the needle during fluoroscopy to minimize radiation to the operator's hands. Once the needle is positioned in this manner, the fluoroscope is turned off and manual needle introduction proceeds.

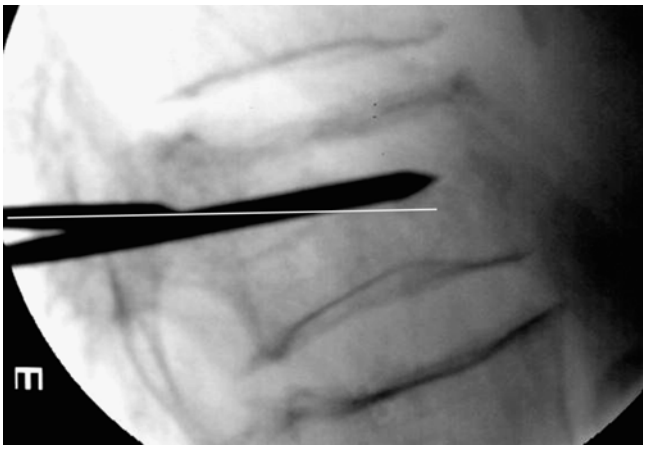


Figure 7.8. Lateral image showing one needle in place with the tip at the junction of the anterior and middle third of the vertebra. This position allows good safety for cement injection away from the large venous confluence in the posterior of the vertebra. The second needle is just beginning to be introduced. The white line shows its trajectory based on its angle of entry. This preliminary evaluation of trajectory allows the operator to predict the ultimate needle tract and make adjustments as the needle is being introduced.

Regardless of whether a transpedicular or parapedicular route has been chosen, the tip of the needle should be ultimately positioned beyond the vertebral midpoint as viewed from the lateral projection. I usually try to obtain an even more anterior position by placing the needle tip at the junction of the anterior and middle thirds (Figure 7.8).

Two needles are routinely placed, usually via the transpedicular approach (Figure 7.9). This takes minimally longer than a single-needle

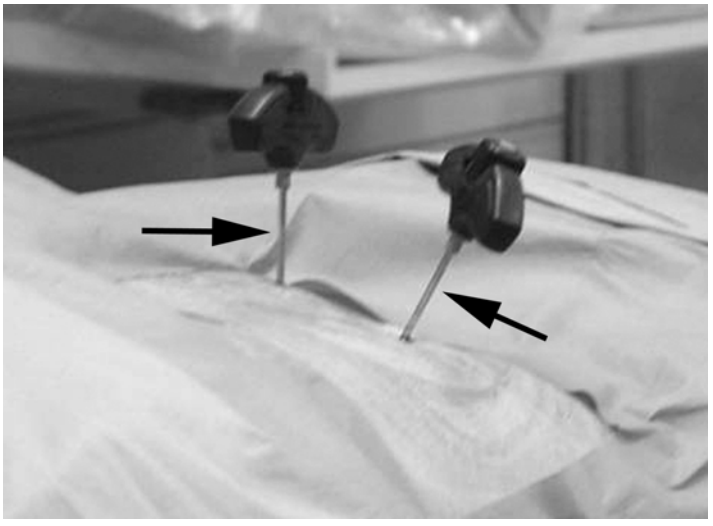


Figure 7.9. Two needles in place (black arrows) for a single-level PV via a transpedicular approach. Both needles are placed prior to cement mixing.

placement and affords a large margin of safety for being able to dependably complete a vertebral fill with a single mix of cement while minimizing cement leaks and maximizing vertebral filling. There is no question that a single-needle placement can give an adequate fill in a large number of cases. However, the single-needle method fails to produce uniform fills more often than the double-needle technique and may cause the operator to accept a larger cement leak during filling (when a leak is seen during injection through the first needle, the operator can finish filling through the second needle and minimize the initial cement leak). Larger leaks occur with one needle because the operator will almost always try to finish a PV through the single existing needle rather than placing a second needle and remixing cement. I teach and routinely use the two-needle technique.

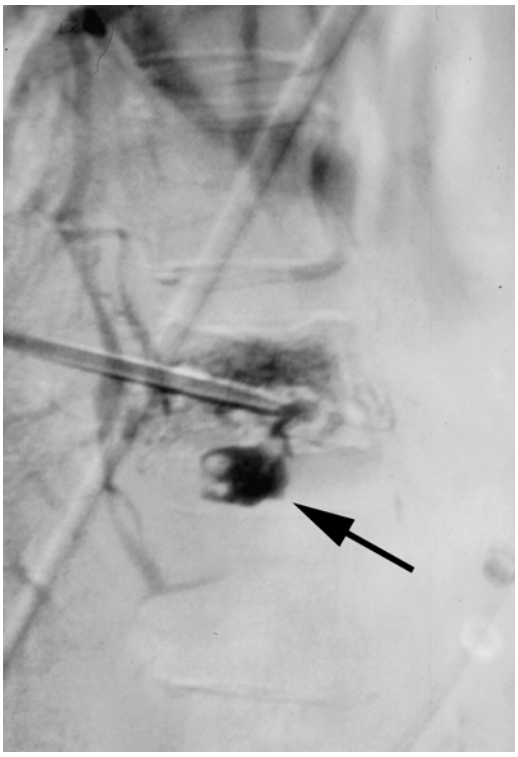
Venography

Venography was never used much in Europe and was introduced in the United States in an attempt to discover potential leak sites using radiographic contrast and prior to injecting cement. However, this worked poorly because the viscosities of contrast and bone cement are very different. The predictive value of where the cement would go by using contrast was low. Occasionally, contrast would pool in a cavity or the disc space and even impede visualization during cement injection (Figure 7.10). Finally, venography increased the radiation burden to the patient and physician, added exposure of contrast to the procedure risks, and was usually very uncomfortable for the patient during the injection. For all these reasons, I discontinued using venography in 1996 and have found no disadvantage or safety loss without its use (5). Other long-term proponents of venography have belatedly stopped its use in routine PV as they found no safety benefit after reviewing their prior cases (6).

Cement Injection

Cement is prepared only after all needles are placed. Spineplex (Figure 7.11A; Stryker-Howmedica), which is now FDA approved for PV and KP, is prepared per the manufacturer's directions using a sterile, vacuum mixing device (Figure 7.11B,C). It is then injected using small syringes (typically 1 cc) or devices made specifically for injection (Figure 7.11C). This allows easy control of the cement introduction. Either the cement injection should be monitored in real time or small quantities (i.e., 0.1–0.2 mL) injected and the result visualized before additional cement is introduced. The latter approach allows monitoring while minimizing the operator's radiographic exposure (as it allows one to step back from the syringe or injection device and minimize exposure during visualization).

Any cement leak outside the vertebral body is an indication to stop the injection. When a rapidly polymerizing cement (e.g., Spineplex) is used, this may be necessary only for a minute or two while the injected



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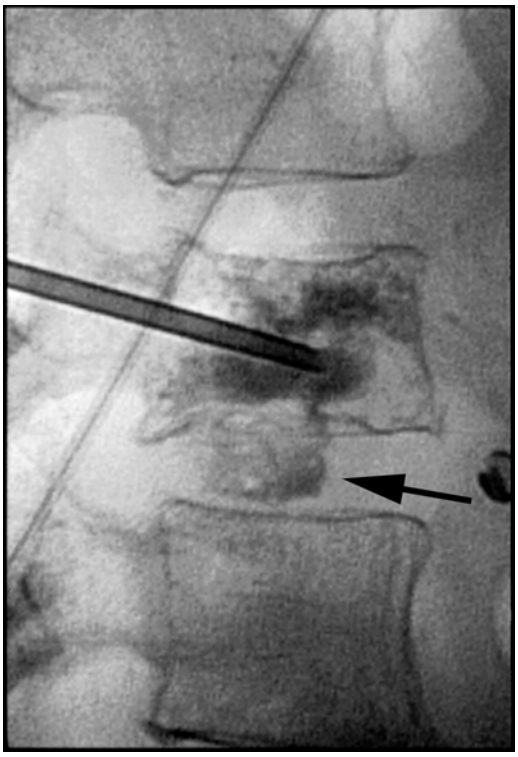

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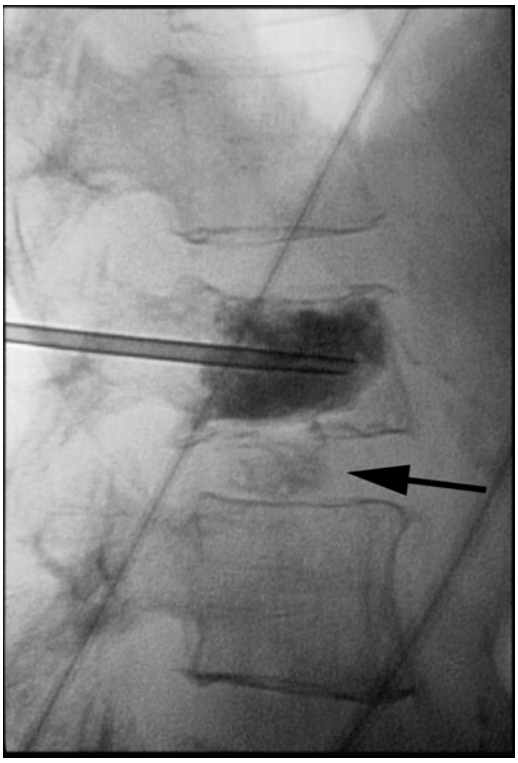

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Figure 7.10. (A) Digital subtraction venogram showing contrast leaking into the disc space (black arrow) through an endplate fracture. This finding would predict a cement leak into the disc through the same hole. **(B)** As cement is injected we see that the contrast that has pooled in the disc space from the venogram slowly goes away (black arrow). Nevertheless, its presence makes it hard to distinguish between residual contrast and potential leak of cement into this area. **(C)** The final image shows good filling of the vertebra with cement and progressive resolution of the contrast in the disc (black arrow). There was no cement leak into the disc, and therefore the contrast leak was not predictive of where the cement would go. Also, the contrast obscures detection of early cement leak in this situation.

Figure 7.11. **(A)** Spineplex is a polymethylmethacrylate specially prepared and FDA approved for PV and KP. It contains 30% barium sulfate by weight, which allows easy visualization of the cement during injection. Mixture of the co-polymer (powder) and monomer (liquid) is adjusted to give adequate room temperature working times for PV and KP. **(B)** This picture shows the "full dose" vacuum mixing device that is supplied in a kit for PV containing two bone needles and multiple syringes for injection. **(C)** The vacuum mixing and injection device shown provides a closed system for mixing and cement delivery. It provides a mechanical advantage during cement injection to facilitate an easier delivery of cement. (Courtesy of Stryker-Howmedica, Kalamazoo, MI.)

cement partially polymerizes and becomes more viscous. Restarting the injection may then redirect flow into other areas of the vertebra away from areas already filled by cement. If leakage is still seen, it is advisable to terminate the cement injection through this needle and move to a second or alternate needle. This will usually allow completion of the vertebral fill without further leakage. The original leak will be occluded by the prior cement injected as it will now have hardened. One should work through a single needle at a time. This avoids contamination of both needles at once and preserves a route (the second needle) for subsequent injection if a leak is encountered early. Injection of thick cement is considered safer than using a very liquid consistency. Cement can still be introduced after the injection devices are no longer able to deliver it. The trocar is useful to push additional thick cement from the cannula into the vertebra. The 5-inch, 13-gauge cannula holds 0.5 mL of cement, and the 5-inch, 11-gauge cannula holds 0.9 mL. Reintroducing the trocar will push this amount of cement (respectively) into the vertebra. This is done only if this additional amount of cement is desired. The cannula can be removed safely without reintroduction of the trocar when the cement is hardened beyond when it can be injected. Simply twisting the needle through several revolutions will break the cement at the tip of the cannula and will prevent leaving a trail of cement in the soft tissues. However, removing the cannula before the cement sufficiently hardens can allow cement to track backward from the bone into the soft tissues and may create local pain (Figure 7.12).

The amount of cement needed to produce pain relief has not been accurately documented in available clinical reports. As we believe pain relief is related to fracture stabilization, the amount of cement needed to restore the initial vertebral body's mechanical integrity should give

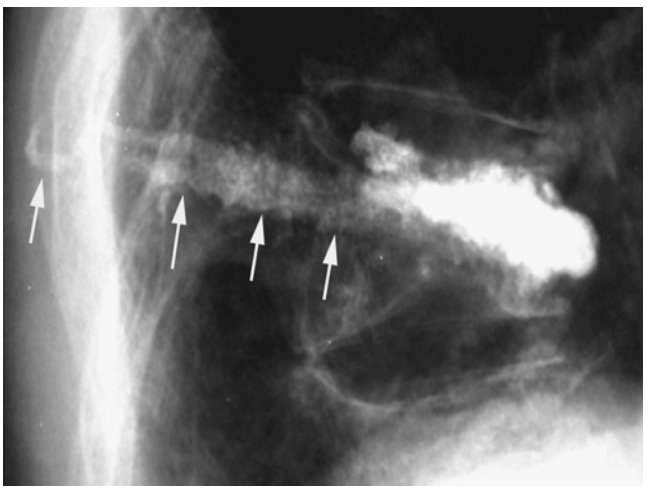


Figure 7.12. Lateral radiograph showing cement that was too liquid when injected that tracked backward along the needle path, leaving cement in the soft tissues (white arrows). This can happen easily when using cements with long work times (i.e., Cranioplastic, Vertebroplastic, or Secore).

an approximation of the quantity needed also to relieve pain clinically. In an in vitro study, we showed that the initial prefracture strength and stiffness of a vertebra could be restored by injecting 2.5–4 mL of Simplex P in a thoracic vertebra, while 6–8 mL provided similar augmentation in the lumbar region (7). A reasonable guideline for the quantity of cement to be injected is the amount that is needed to fill 50%–70% of the residual volume of the compressed vertebra (Figure 7.13). These amounts should not be taken as an absolute but rather as a guide. This indicates that relatively small amounts of cement are needed to restore vertebral biomechanical strength and that these amounts vary with the vertebral level in the spine, an individual's body size, and the degree of vertebral collapse.

We have also demonstrated that significant strength restoration is provided to the vertebral body with a unipedicular injection when cement filling crosses the midline of the vertebral body (8). This would suggest that unipedicular fills that achieve adequate cement injection volumes and distribution are likely to be successful at achieving pain relief. This fact notwithstanding, there is a higher likelihood of achieving more uniform fills, with smaller leaks, while using two needles rather than one.

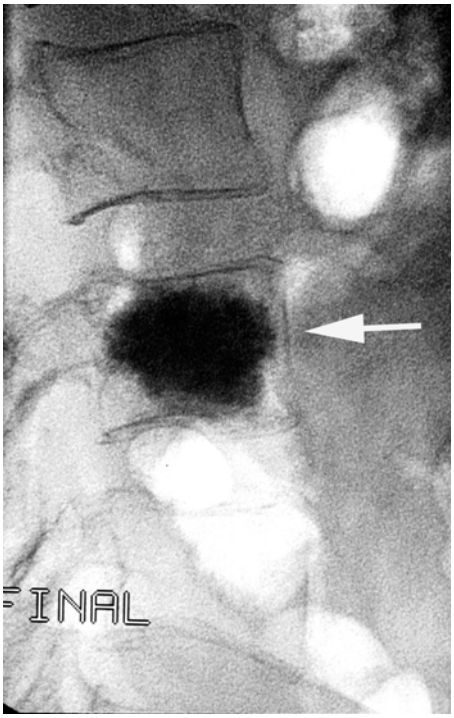
Postprocedure Care

After adequate vertebral filling has been achieved, the needles are removed. Occasionally, venous bleeding is experienced at the needle entry site. Hemostasis is easily achieved with local pressure for 3–5 minutes. The entry site is dressed with betadine ointment and a sterile bandage. The patient is maintained recumbent for 1–2 hours after the procedure and monitored for changes in neurologic function or for signs of any other clinical change or side effects (Table 7.2).

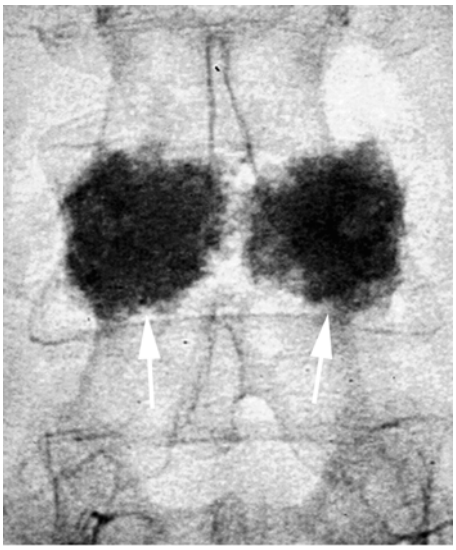
Any sign of adverse affect should trigger a search of the explanatory cause using appropriate imaging modalities (usually CT). It is well known that 1%–2% of patients will have a transient period of benign increase in local pain following PV. However, this is a diagnosis of exclusion, and increased pain should prompt extended monitoring (or hospitalization if the pain is severe and requires aggressive therapy) and imaging evaluation to exclude other causes for the pain (such as cement extravasation). Pain alone will usually be adequately treated with analgesics, nonsteroidal anti-inflammatory drugs (such as Toradol), or local steroid injections adjacent to affected nerve roots or into the epidural space. Large cement leaks or neurologic dysfunction should prompt an immediate surgical consultation.

Percutaneous vertebroplasty is easily performed on an outpatient basis with the patient discharged after 2 hours of uneventful recovery. (Table 7.2). Follow-up is indicated to monitor the results of therapy and should be incorporated into a quality management program. Complications and results should be maintained by the facility as well as for each individual provider. Additional information and recommendations about the credentialing and quality management for PV can be

Figure 7.13. Lateral **(A)** and anteroposterior **(B)** radiographs following a bilateral transpedicular PV reveals 70% or greater filling (white arrow in A) with no evidence of leak. It is important to fill the anterior 2/3–3/4 of the vertebral body. In the anteroposterior view, cement should cross the midline to reinforce both halves of the vertebra (white arrows). **(C)** Anteroposterior radiograph of a unipedicular PV shows distribution of cement into both halves of the vertebra.



A



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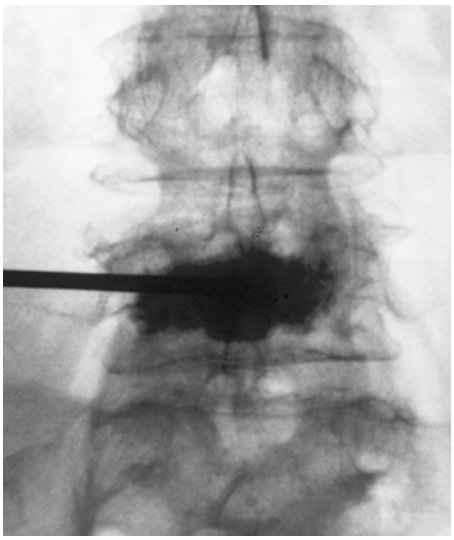

C

Table 7.2. Sample Postprocedure Orders and Discharge Instructions.

Postprocedure
Bed rest 1 hour postprocedure (may roll side to side)
May sit up after 1 hour with assistance
Vital signs and neurologic examinations (focused on the lower extremities) every 15 minutes for the first hour, then every 30 minutes for the second hour
Record pain level (visual analog scale, 1 to 10) at end of procedure and at 2 hours postprocedure (before discharge). Compare with baseline values and notify physician if pain increases above baseline
May have liquids by mouth if no nausea
Discontinue oxygen (if used) after procedure (if saturation is normal)
Discontinue intravenous drips after 1 hour if recovery is otherwise uneventful
Discharge patient home with adult companion after 2 hours if recovery is uneventful
Discharge
Return home; bed rest or minimal activity for next 24 hours
May resume regular diet and medications
Keep operative site covered for 24 hours. Bandages may then be removed and site washed with a damp cloth. Do not soak
Notify physician/facility if you have increasing pain, redness, swelling, or drainage from the operative site
Notify physician/facility if you have difficulty with walking, changes in sensation in your hips or legs, new pain, or problems with bowel or bladder function
The area of your procedure will be tender to the touch for 24 to 48 hours. This is to be expected
If you continue to have pain similar to that before your procedure, you may continue to take prescribed pain medications as needed

found in the standards of practice published by the American College of Radiology or Society of Interventional Radiology (see Chapter 14).

Results

Relatively few prospective trials are available looking at the results of PV. Zoarski et al. (9) presented a small prospective (nonrandomized) evaluation of the effectiveness of PV for relieving pain. This report utilized the MODEMS method to establish that 22 of 23 patients improved after PV and remained satisfied during the 15–18 month follow-up period. McGraw et al. (10) prospectively treated and evaluated 100 patients with PV looking at pain scores before and after the procedure. They found a statistically significant improvement in pain following PV (10). Additionally, numerous retrospective series are available and uniformly report good pain relief and reduced requirements for analgesics following PV (2,11–14). This is especially true of pain related to compression fractures produced by osteoporosis where significant pain relief of between 80% and 90% has been observed. This pain relief is persistent with rare reports of additional compression of vertebra previously treated with PV (15). Additional fractures at other levels remain a possibility and primary source of morbidity. Once osteoporotic

compression fracture occurs, every effort to minimize future bone loss medically should be made. Also, modifications in lifestyle should be attempted to minimize mechanical stress on the spine and thereby lessen the risk of additional fractures.

Complications

Complications were initially considered and reported as low. Unfortunately, complications are higher for inexperienced physicians and for those who attempt the procedure without adequate image guidance or appropriate materials. Adequate training needs to be completed before attempting the procedure. Recommendations can be obtained from the American College of Radiology Standards of Practice on Percutaneous Vertebroplasty or the Society of Interventional Radiology (see Chapter 14). A complete discussion of known and potential complications and methods for complication avoidance is given in Chapter 13.

In osteoporotic induced vertebral fractures, clinical reports of complications are around 1% (11–14). Many of these are transient and include short-term increase in local pain after cement introduction (nonradicular and not associated with neurologic deficit). This is usually easily treated with nonsteroidal anti-inflammatory drugs and resolves within 2–24 hours. Uncommonly, cement leaking from the vertebra adjacent to a nerve root may produce radicular pain. Analgesics combined with local steroid and anesthetic injections usually provide adequate relief. A trial of this type of therapy is warranted as long as there are no associated motor deficits. The discovery of a motor deficit (or bowel or bladder dysfunction) should initiate an immediate surgical consult. This type of severe complication will almost always be associated with large volume leaks that result in neurologic compression. Severe complications are rare in the hands of experienced operators.

Cement leaks have also been implicated in producing pulmonary embolus (11). These are usually not symptomatic but rarely have produced the clinical symptoms accompanying pulmonary infarct. With a right-to-left shunt this can result in cerebral infarct (16). Patients should be categorized into low or high pulmonary risk on the basis of existing pulmonary function. Those with severe respiratory disability should have limited procedures to minimize adverse effects of even small embolic events.

Infection has been rare with PV, with only a single case reported in the literature (15).

The complication rate found when treating compression fractures resulting from malignant tumors is considerably higher than complications found in osteoporosis (13,17–20). This occurs because there are frequently areas of destroyed bone involving the vertebral cortex creating more of a propensity for cement to leak into the surrounding tissues or vessels. Cement leaks resulting in symptomatic complications occur in up to 5% of patients in this setting. These difficult cases should be undertaken only by experienced individuals.

Death is a known complication of PV. Nussbaum et al. (21) reported death in 1/50,000 cases of both PV and KP. These may be related to severe allergic reactions to the bone cement or to pulmonary compromise created by cement or fat emboli. The risk of this extreme complication increases with the number of levels performed during each session. Mathis et al. (4) reported the first multilevel PV therapy treating seven vertebrae in a 35-year-old with multiple fractures associated with steroid use for lupus. This patient's therapy occurred in three treatment sessions. Because the introduction of cement is a hydraulic event with as much marrow pushed out of the trabecular space as cement injected, there is concern about fat emboli in large-volume cement injections. I recommend treating no more than three vertebrae in any one session. Additionally, there are no data that support the prophylactic use of PV to treat vertebrae that are believed to be at risk of fracture. Except for prophylactic use, there is little conceivable reason to perform PV on large numbers of vertebrae at one time.

Any deviation from an expected good result (such as increased pain or neurologic compromise) should initiate an immediate imaging search with CT to look for a cause of the clinical change. Unremitting or progressive symptoms may require surgical or aggressive medical intervention, and outpatients should be hospitalized and monitored.

Conclusions

Percutaneous vertebroplasty has been shown to be very effective at relieving the pain associated with compression fractures of vertebra caused by both primary (age-related) and secondary (steroid-induced) osteoporosis. It also has substantial benefit in neoplastic-induced vertebral compression fracture pain but with a higher chance of associated complication. Percutaneous vertebroplasty is rapidly becoming the standard of care for compression fracture pain not responding to conservative medical therapy. However, this simple procedure must be treated with respect, as its application, without appropriate preparation and physician knowledge, can quickly produce increased pain, permanent neurologic injury, and even death.

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