Percutaneous vertebroplasty, among various other options, has become a mainstay in the management of osteoporotic and malignant vertebral fractures. The purpose of this article is to describe complications arising from the procedure, which can be classified as mild, which may include a temporary increase in pain and transient hypotension; moderate, including infection and extravasation of cement into the foraminal, epidural or dural space; and severe such as cement leakage in the paravertebral veins, leading to pulmonary embolism, cardiac perforation, cerebral embolism or even death. Vertebroplasty is not a procedure without complications. The article defines them and describes methods to minimize them.

Mild complications
The following are considered mild complications: a temporary increase in pain after the procedure; transient arterial hypotension; cement leakage into the intervertebral disc space and into paravertebral soft tissues. Moderate complications include infection and cement leak into the epidural space. Severe complications include leak into the paravertebral veins, leading to pulmonary embolism, cerebral embolism or cardiac perforation. The complications of vertebroplasty can be classified as follows: mild, moderate and severe.

Moderate complications
These include infection, cement leak into the epidural/foraminal space and misplaced needle in the tract. Infection is a risk in any percutaneous procedure. It is a complication that can be eliminated or minimized. Possible results of infection are discitis, osteomyelitis; or even an epidural infection can occur and can be catastrophic with surgery required to remove the cement which serves as a nidus for infection.
Figure 1. Lateral fluoroscopic view in a 49-year-old man with osteoporotic fracture of L3. Needle is in the anterior aspect of the vertebral body with cement extravasating into the L2/3 disc space (arrow).

Figure 2. (a) Axial CT scan of a 19-year-old female with heavy steroid use for Wegner granulomatosis, 30 minutes post-vertebroplasty, showing cement leak into the paravertebral soft tissues (arrows) and muscles. (b) Sagittal reformat CT scan in the same patient; arrow shows the extent of the leak.

Figure 3. Coronal reformat CT shows a new fracture of T11 (arrow) in a 66-year-old osteoporotic woman who had undergone percutaneous vertebroplasty of T9 and T10 3 months ago, presenting with new severe back pain.

Figure 4. Lateral fluoroscopic image during placement of an osteoplasty needle for vertebroplasty of T11 in a 49-year-old osteoporotic man. Arrow shows an epidural leak.

Figure 5. CT scan of the thoracolumbar spine post-vertebroplasty. Arrow points to the foraminal leak.
Extravasation of cement into the epidural (Figure 4) or foraminal space (Figure 5) is a rare complication. Most cases are clinically silent if not for post-procedure CT. The prevalence may be as high as 40%,12-14 Chiras et al15 reported paraplegia due to cement-related spinal cord compression to occur in only 0.4% of patients. Needle traversing of the lamina instead of the pedicle can occur, especially in the thoracic vertebra, where the pedicle is smaller, and can lead to catastrophic complications (Figure 6).

Severe complications
Severe complications are usually related to cement leakage into the paravertebral veins leading to pulmonary embolism, cardiac perforation, cerebral embolism and even death. Paravertebral venous leak can be due to a combination of highly vascular lesions and liquid consistency of the cement. This leak may also produce radicular pain (Figure 7). Pulmonary cement embolism (Figure 8) is a rare complication of vertebroplasty.16 It can be asymptomatic and is reported to occur in up to 4.6% of the cases and is directly related to the frequency of paravertebral venous leak, but not to the number of vertebral bodies treated.17 If symptomatic, then classical findings of chest discomfort, hypotension, dyspnea would be observed.18 Onset can be immediate or delayed and ultimately can lead to death.19 It is managed with oxygen inhalation; short-term anticoagulation therapy; IV steroid therapy; or in severe cases, IV steroid therapy with catheter-aided interventional techniques.18-21

Cardiac perforation is an extremely rare complication of vertebroplasty, with only one case report in the

Figure 6. CT scan of the thoracic spine in a 79-year-old woman who underwent vertebroplasty of T11. Arrow points to lamina puncture instead of pedicle in this post-procedure CT.

Figure 7. Lateral fluoroscopic view in a 77-year-old osteoporotic woman who suffered a fracture of T11 and T12, with arrow pointing to a paravertebral venous leak.

Figure 8. Non-enhanced CT scan of chest done in a 45-year-old woman who underwent vertebroplasty of L4 the previous day. She was complaining of chest pain and dyspnea. Arrow points to a pulmonary cement embolus.
literature, and is potentially fatal and a cause of hemorrhagic cardiac and tamponade.\textsuperscript{22} Cerebral embolus has been reported to occur and is attributed to fat emboli from raised intramedullary pressure during cementation.\textsuperscript{23} When systemic embolus is seen, it is attributed to paradoxical cerebral arterial embolization of cement via a patent foramen ovale.\textsuperscript{24} Sudden cardiovascular collapse and death during this procedure have been reported. Autopsy results demonstrate fat, bone spicules, and polymethyl methacrylate in the lungs.\textsuperscript{25}

### Techniques to minimize complications

Techniques include (a) choosing a transpedicular route in the lumbar spine and choosing the costovertebral junction in the thoracic spine, (b) avoiding a cortical breach whenever possible, (c) optimizing opacification of cement by following the manufacturer recommendations and by not altering recommended proportions of powder polymer and liquid polymer, and (d) defining optimal cement viscosity before injection. If cement leakage occurs, cessation of the procedure is recommended.\textsuperscript{26}

### REFERENCES

1. Cotten A, Boutry N, Cortel B, Assaker R, Demon-dion X, Leblond D, et al. Percutaneous Vertebroplasty: State of art. Radiographics 1998;18:311-20.
2. Vasconcelos C, Galloïd P, Martin JB, Murphy KJ. Transient arterial hypotension induced by polymethylmethacrylate injection during percutaneous vertebroplasty. J Vasc Inter Radiol 2001;12:1001-2.
3. Lin EP, Ekholm S, Hiwatashi A, Westesson PL. Vertebroplasty: Cement leakage into the disc increases the risk of new fracture of adjacent vertebral body. AJNR Am J Neuroradiol 2004;25:175-80.
4. Peh WC, Gilula LA, Peck DD. Percutaneous vertebroplasty for severe osteoporotic vertebral body compression fractures. Radiology 2002;223:121-6.
5. Gilula L. Is insufficient use of polymethylmethacrylate a cause for vertebroplasty failure necessitating repeat vertebroplasty? AJNR Am J Neuroradiol 2003;24:2120-2.
6. Ryu KS, Park CK, Kim MC, Kang JK. Dose-dependent epidural leakage of polymethylmethacrylate after percutaneous vertebroplasty in patients with osteoporotic vertebral compression fractures. J Neurosurg 2002;96:56-61.
7. Jensen ME, Evans AJ, Mathis JM, Kallmes DF, Cloft HJ, Dion JE. Percutaneous polymethylmethacrylate vertebroplasty in the treatment of osteoporotic vertebral body compression fractures: Technical aspects. AJNR Am J Neuroradiol 1997;18:1897-904.
8. Laredo JD, Hamze B. Complications of vertebroplasty and their prevention. Semin Ultrasound CT MR 2005;26:65-80.
9. Upin AA, Hirsh JA, Centenera LV, Pfiefer BA, Pazianos AG, Choi IS. Occurrence of new vertebral body fracture after percutaneous vertebroplasty in patients with osteoporosis. Radiology 2003;226:119-24.
10. Chiras J, Deramond H. Complications des vertebroplasties. In: Sallant G, Laville, C, editors. Echecs CT complications de la chirurgie du rachis: Chirurgie de reprise. Paris, France: Sauramps Medical; 1995. p. 149-53.
11. Yu SW, Chen WJ, Lin WC, Chen YJ, Tu YK. Sero-us pyogenic spondylitis following vertebroplasty: a case report. Spine 2004;29:E209-11.
12. Cotten A, Dewatre F, Cortel B, Assaker R, Leblond D, Duquesnoy B, et al. Percutaneous vertebroplasty for osteolytic metastasis and myeloma. Radiology 1996;200:525-30.
13. Ratliff J, Nguyen T, Heiss J. Root and spinal cord compression from methylmethacrylate vertebroplasty. Spine 2001;26:E300-2.
14. Lopes NM, lopes VK. Paraplegia complicating percutaneous vertebroplasty for osteoporotic vertebral body fracture: Case report. Arq Neuropsiquiatr 2004;52:879.
15. Chiras J, Depriester C, Well A, Sola-Martinez MT, Deramond H. Percutaneous vertebroplasty surgery: techniques and indications. J Neuroradiol 1997;24:45-59.
16. Jiang JS, Lee SH, Jung SK. Pulmonary embolism of polymethylmethacrylate following percutaneous vertebroplasty: A report of three cases. Spine 2002;27:E416-8.
17. Yoo KY, Jeong SW, Yoon W, Lee J. Acute respiratory distress syndrome associated with pulmonary cement embolism following percutaneous vertebroplasty. Spine 2004;29:E294-7.
18. Syed MI, Jan S, Patel NA, Shaikh A, Marsh RA, Stewart IV. Fatal fat embolism after vertebroplasty: Identification of the high-risk patient. AJNR Am J Neuroradiol 2006;27:343-5.
19. Yoo KH, Jeong SW, Yoon W. Acute respiratory distress syndrome associated with pulmonary cement embolism following percutaneous vertebroplasty with polymethylmethacrylate. Spine 2004;29:E294-7.
20. Jiang JS, Lee SH, Jung SK. Pulmonary embolism of polymethylmethacrylate after percutaneous vertebroplasty: A report of three cases. Spine 2002;27:E416-8.
21. Yoo KY, Jeong SW, Yoon W, Lee J. Acute respiratory distress syndrome associated with pulmonary cement embolism following percutaneous vertebroplasty with polymethylmethacrylate. Spine 2004;29:E294-7.
22. Kim SY, Seo JB, Do KH, Lee JS, Song KS, Lim TH. Cardiac perforation caused by acrylic cement: A rare complication of percutaneous vertebroplasty. Am J Roentgenol 2005;185:1295-7.
23. Edmonds CR, Barbut D, Hager D, Sharrock NE. Intraoperative cerebral arterial embolization during total hip arthroplasty. Anesthesiology 2000;93:A15-8.
24. Christie J, Burnett R, Potts HR, Pell AC. Echocardiography of transatrial embolism during cemented and uncemented hemiarterioplastic of the hip. J Bone Joint Surg Br 1984;67:409-12.
25. Childers JC Jr. Cardiovascular Collapse and Death during Vertebroplasty [letter]. Radiology 2003;228:902-3.
26. Heran MK, Legiehn GM, Munk PL. Current concepts and techniques in percutaneous vertebroplasty. Orthop Clin North Am 2006;37:409-34.