

Cardiac Emboli Documented by Intraoperative Transesophageal Echocardiogram During Administration of a Topical Hemostatic Agent Prior to Pedicle Subtraction Osteotomy

Neil L. Duplantier, MD,* Michael Couch, MD,[†] Logan Emory, MD,[†] and Joseph M. Zavatsky, MD[‡]

Study Design. This is a case report.

Objective. Describe the occurrence of cardiac emboli recorded on transesophageal echocardiogram (TEE) after the injection of a topical hemostatic agent into a vertebra prior to performing a pedicle subtraction osteotomy (PSO).

Summary of Background Data. Hemostasis during spinal surgery is critical for adequate visualization and to reduce the risk of perioperative complications. Adult spinal deformity surgery can involve performing PSOs which are useful in cases of fixed spinal deformities and are associated with increased blood loss secondary to epidural and cancellous bleeding. Prior to performing a PSO, a topical hemostatic agent can be injected into the vertebra through the pedicle screw pilot holes in an attempt to decrease cancellous bleeding. Injected hemostatic agents can pressurize the vertebral body similar to cementation in vertebroplasty and during fracture reaming and prosthetic implantation in the femur. Patients with cardiac defects such as patent foramen ovale or atrial septal defect may be more prone to systemic embolic events resulting in morbidity or mortality.

Methods. We injected a topical hemostatic matrix agent through the pedicle screw pilot holes into the L1 vertebral body prior to performing a PSO while simultaneously recording with TEE.

Results. The TEE recorded large visible emboli traveling through the heart into the pulmonary vasculature. The patient remained stable throughout the remainder of the case and a

postoperative spiral computed tomography (CT) scan was negative for filling defects. The patient had an uneventful hospital course.

Conclusion. Questions remain about the exact consistency of these emboli, when they are most likely to occur, how much cardiopulmonary insult can be tolerated without resulting in complications, or how to prevent their occurrence. Patients undergoing spinal surgery with the plan to inject hemostatic matrix agents into the vertebral body may benefit from a preoperative TEE to reduce the risk of complications associated with embolic events, especially in patients with undiagnosed patent foramen ovale or atrial septal defect.

Key words: complication, emboli, hemostasis, pedicle subtraction osteotomy, PSO, SurgiFlo, topical hemostatic matrix.

Level of Evidence: 5

Spine 2016;41:E556–E560

Hemostasis during spinal surgery is critical for adequate visualization and to prevent complications. Spinal deformity corrective surgery can involve one or more osteotomy types. Pedicle subtraction osteotomies (PSOs) are extremely useful in cases of fixed spinal deformities, but associated with increased intraoperative blood loss.¹

Multiple hemostatic matrix agents are available for use during spine surgery.^{2–4} Prior to a PSO, topical hemostatic matrices such as SurgiFlo (Ethicon Inc., West Somerville, NJ) can be injected through the pedicle screw pilot holes, pressurizing the vertebral body in an attempt to decrease the cancellous bleeding associated with the procedure. Similar documented increases in pressure occur in the femoral canal during reaming and IM nail placement, and in the vertebra with cementation in vertebroplasty with documented embolic events entering the pulmonary vasculature.^{5–7} However, the exact make up of the embolic material seen on transesophageal echocardiogram (TEE), as well as their effect on the patients' cardiopulmonary physiology is unknown.⁸

From the *Department of Orthopedic Surgery; [†]Department of Anesthesiology, Ochsner Clinic Foundation, New Orleans, LA; and [‡]Spine & Scoliosis Specialists, Tampa, FL.

Acknowledgment date: June 22, 2015. First revision date: September 29, 2015. Acceptance date: October 6, 2015.

The device(s)/drug(s) is/are Food and Drug Administration–approved or approved by corresponding national agency for this indication.

No funds were received in support of this work.

No relevant financial activities outside the submitted work.

Address correspondence and reprint requests to Joseph M. Zavatsky, MD, Spine & Scoliosis Specialists, 14505 University Point Place, Tampa, FL 33613, 1 813 985 7908; E-mail: josephzavatsky@yahoo.com

DOI: 10.1097/BRS.0000000000001307

E556 www.spinejournal.com

May 2016

Copyright © 2016 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

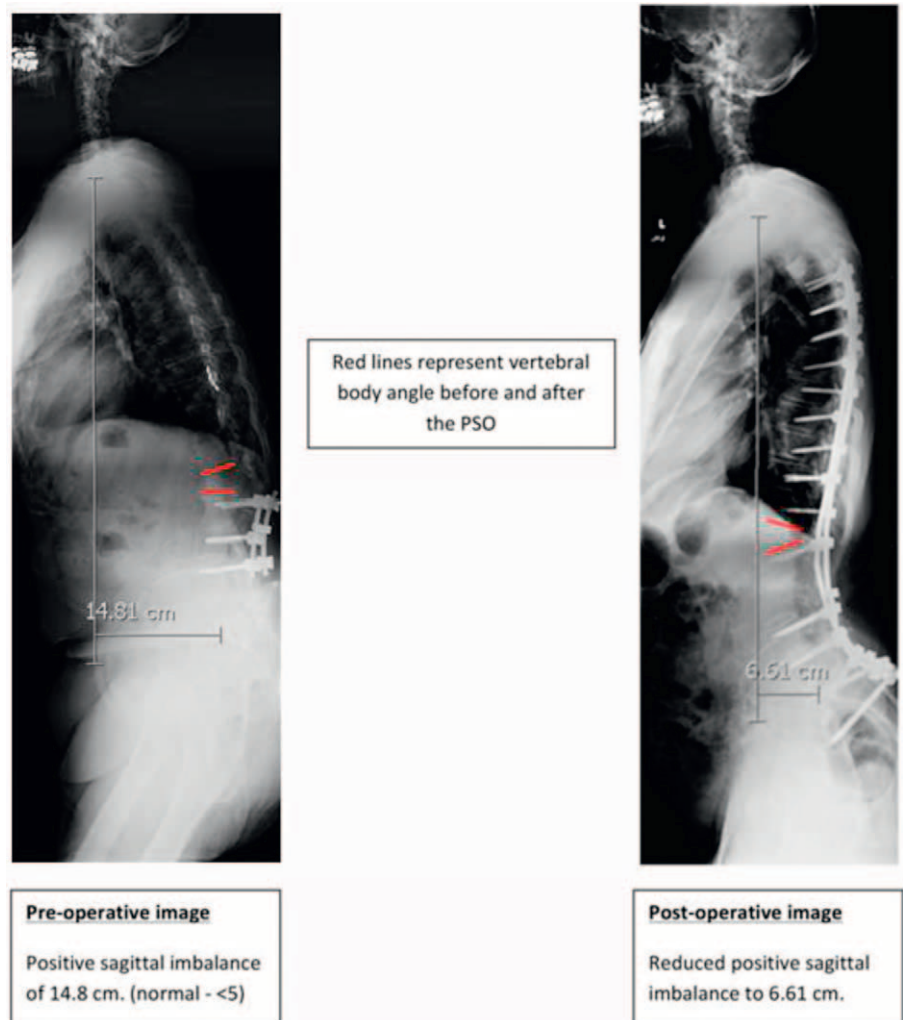


Figure 1. Depicts the presurgical and postsurgical lateral full length standing radiographs with positive sagittal imbalance measurements.

We are unaware of any previously published reports of cardiac emboli occurring after the pressurization of a vertebral body with a hemostatic matrix agent while performing a PSO.

CASE REPORT

A 72-year-old man with a previous L2-L4 decompression and fusion presented with a positive sagittal imbalance of +14 cm complaining of worsening back pain and the sensation of constantly leaning forward (Fig. 1). The patient had failed all nonsurgical measures, and his symptoms were significantly affecting his activities of daily living. The patient suffered from severe congestive heart failure with an ejection fraction of 30%, a left bundle branch block, and dilated cardiomyopathy.

The cardiac anesthesia service continuously monitored the patient's cardiac function utilizing a TEE throughout the case. The patient underwent a revision posterior spinal fusion T4-ileum, L1 PSO, T12-L2, and L5-S1 Smith Peterson osteotomies (SPOs), L5-S1 transforaminal

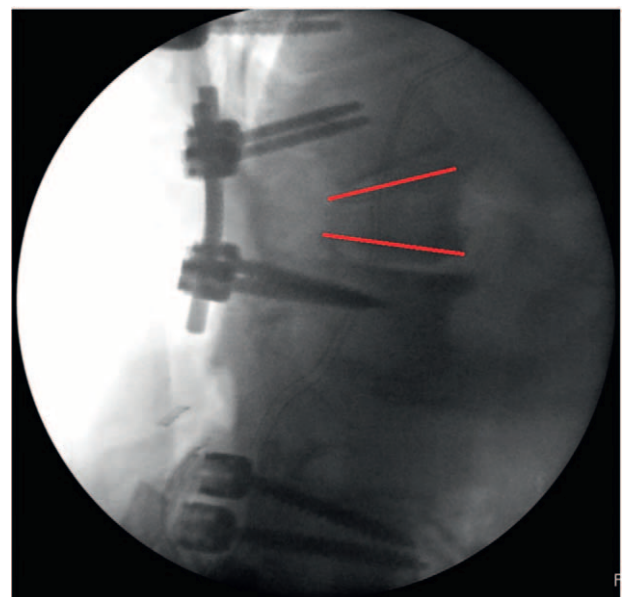


Figure 2. Depicts the intraoperative fluoroscopy image immediately after the pedicle subtraction osteotomy at the L1 vertebral level.

lumbar interbody fusion (TLIF) with cage, and T3 prophylactic vertebroplasty (Figs. 1 and 2).

A hemostatic matrix (SurgiFlo) was injected through the pedicle screw pilot holes prior to the PSO procedure. Immediately after the matrix was injected, TEE recorded large emboli moving from the right atrium through the right side of the heart into the pulmonary artery (Fig. 3). No abnormal findings in heart rate, blood pressure,

respiratory status, or oxygen saturation were associated with the emboli. The emboli were visualized immediately after the pressurization of each pedicle and then visualized for one full cardiac cycle. No additional emboli were visualized during the procedure including the T3 vertebroplasty. Immediate postoperative spiral computed tomography (CT) scan of the chest did not demonstrate any abnormality.

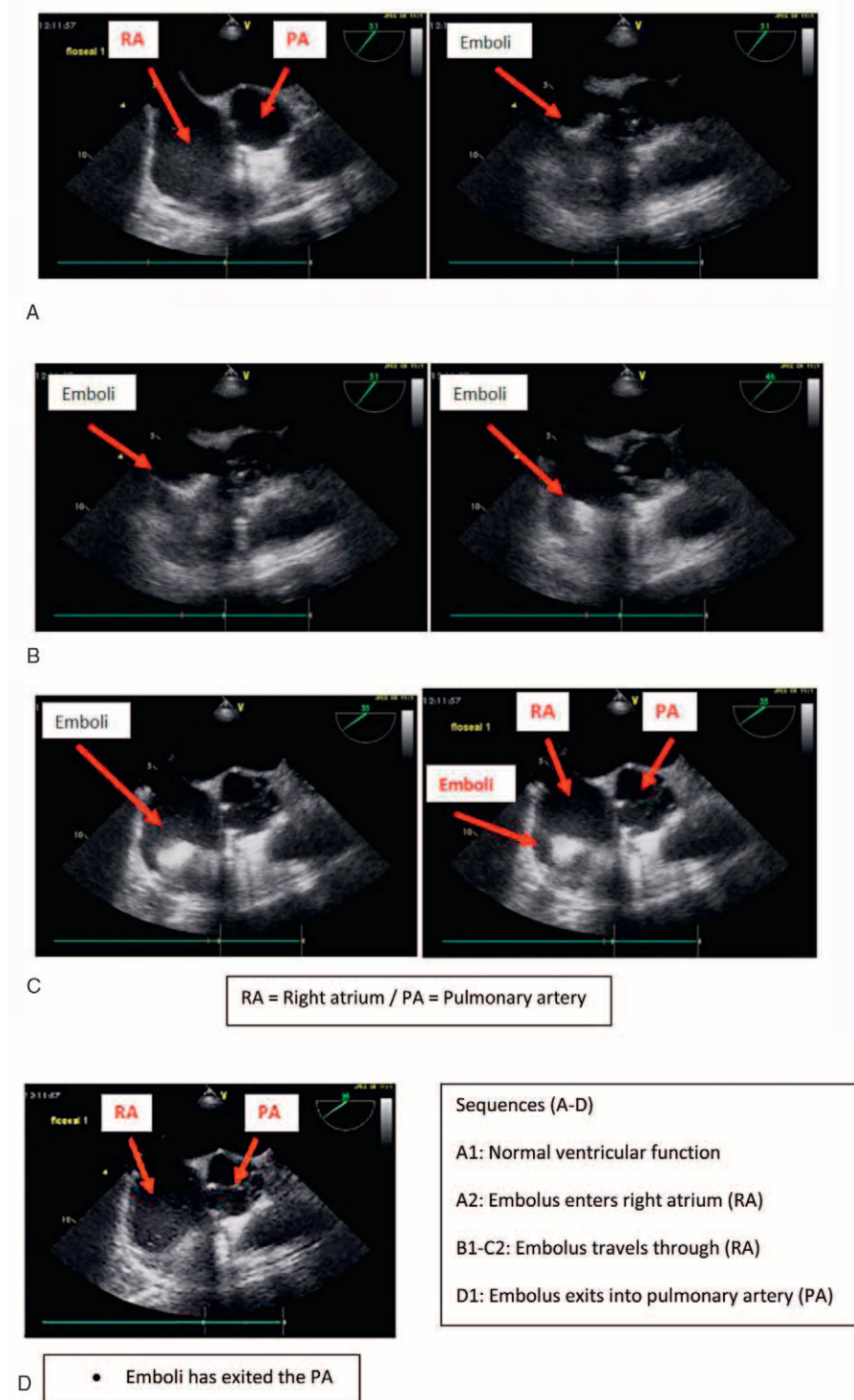


Figure 3. Depicts a sequence of transesophageal echocardiogram images showing an embolus entering the heart and exiting into the pulmonary vasculature.

DISCUSSION

Cardiac emboli have been documented during pressurization of long bones such as the femur.^{5,6} Likewise, fat embolism syndrome has been described in both long bone fractures and with vertebral pressurization during vertebroplasty, with associated fatalities.^{7,9-14} However, to our knowledge this is the first report of cardiac emboli resulting after pressurization of a vertebra with a hemostatic agent during a PSO. The patient had significant baseline cardiopulmonary compromise but experienced no adverse events related to the emboli, suggesting that limited amounts of cardiac emboli during spine surgery may be tolerated even in the setting of poor cardiopulmonary reserve. However, it is unknown to what extent this can be tolerated.

The echogenic embolic material found in previous intramedullary (IM) femoral nailing studies demonstrated the presence of fat and fresh thrombotic material.⁸ Large fat droplets may be released into the systemic circulation following raised intravertebral pressure, which could potentially obstruct end capillary beds mechanically. Without a tissue sample, the exact make up of our patient's embolus is unknown, but is likely consistent with fat and thrombotic material Bisignani *et al*⁸ found with the IM reaming of long bones.

Patent foramen ovale (PFO) has been reported in 27% of the individuals at autopsy and in 25.6% of randomly selected individuals through TEE.¹⁵⁻¹⁷ A right to left heart shunt such as a PFO or atrial septal defect (ASD) are concerning because a paradoxical embolism traveling from the right heart directly to the left heart into the circulatory system could result in a severe embolic event such as a stroke, ischemic bowel, or a nonperfused extremity.

Prone surgery, positive pressure ventilation, and replacement of blood loss with intravascular fluid boluses may potentiate emboli to cross through defects in the heart becoming systemic.¹⁵⁻¹⁷ Our patient did not have a septal defect nor did he exhibit symptoms to suggest a systemic embolic event postoperatively. However, patients with a preexisting PFO or ASD may be more susceptible to complications associated with such embolic events.

CONCLUSION

Emboli appear to be more common during procedures that result in the internal pressurization of the skeleton.⁵⁻⁷ Questions remain about the consistency of these emboli, when they are most likely to occur, how much cardiopulmonary insult can be tolerated, and how to prevent their occurrence. Fat embolism syndrome, although rare, is a potentially fatal complication associated with pressurization of the skeleton. It is important to consider this complication with long bone and vertebral body pressurization. Surgeons must be aware of the potential complications associated with pressurization of the vertebral body and should carefully consider a preoperative TEE to evaluate for a PFO or ASD to reduce the risk of complication from an embolic event and consider this risk in the consent

procedure. Further prospective analysis is warranted to assess the effects of pressurization of the vertebral body during PSO.

➤ Key Points

- ❑ Emboli have been documented during procedures involving pressurizing the skeleton.
- ❑ Questions remain regarding the amount of cardiopulmonary insult that can be tolerated during vertebral body pressurization.
- ❑ Asymptomatic PFO and ASD are common, and can result in paradoxical emboli traveling from the right to the left side of the heart and into the circulatory system.
- ❑ Patients with preexisting PFOs or ASDs may be more susceptible to complications associated with such embolic events.
- ❑ Surgeons must be aware of the potential complications associated with pressurization of the vertebral body and should carefully consider a preoperative TEE to evaluate for a PFO or an ASD to reduce the risk of complication from an embolic event.

References

1. Birdwell KH, Lewis SJ, Rinella A, et al. Pedicle subtraction osteotomy for the treatment of fixed sagittal imbalance. *J Bone Joint Surg Am* 2004;86-A (suppl 1):44-50.
2. Wang GJ, Hungerford DS, Savory CG, et al. Use of fibrin sealant to reduce bloody drainage and hemoglobin loss after total knee arthroplasty: a brief note on a randomized prospective trial. *J Bone Joint Surg Am* 2001;83-A:1503-5.
3. Renkens KL Jr, Payner TD, Leipzig TJ, et al. A multicenter, prospective, randomized trial evaluating a new hemostatic agent for spine surgery. *Spine* 2001;26:1645-50.
4. Woodworth BA, Chandra RK, LeBenger JD, et al. A gelatin-thrombin matrix for hemostasis after endoscopic sinus surgery. *Am Otolaryngol* 2009;30:49-53.
5. Wenda K, Runkel M, Degreif J, et al. Pathogenesis and clinical relevance of bone marrow embolism in medullary nailing—demonstrated by intraoperative echocardiography. *Injury* 1993;suppl 3:S73-81.
6. Wolinsky P, Tejwani N, Richmond JH, et al. Controversies in intramedullary nailing of femoral shaft fractures. *Instr Course Lect* 2002;51:291-303.
7. Ahmadzai H, Campbell S, Archis C, et al. Fat embolism syndrome following percutaneous vertebroplasty: a case report. *Spine J* 2014;14:e1-5.
8. Bisignani G, Bisignani M, Pasquale GS, et al. Intraoperative embolism and hip arthroplasty: intraoperative transesophageal echocardiographic study. *J Cardiovasc Med (Hagerstown)* 2008; 9:277-81.
9. Aebli N, Krebs J, Davis G, et al. Fat embolism and acute hypotension during vertebroplasty: an experimental study in sheep. *Spine* 2002;27:460-6.
10. Aebli N, Krebs J, Schwenke D, et al. Pressurization of vertebral bodies during vertebroplasty causes cardiovascular complications: an experimental study in sheep. *Spine* 2003;28:1513-20.
11. Krebs J, Ferguson SJ, Hoerstrup SP, et al. Influence of bone marrow fat embolism on coagulation activation in the ovine model of vertebroplasty. *J Bone Joint Surg Am* 2008;90:349-56.

12. Aebli N, Schwenke D, Davis G, et al. Polymethylmethacrylate causes prolonged pulmonary hypertension during fat embolism. *Acta Orthop* 2005;76:904–11.
13. Aebli N, Krebs J, Schwenke D, et al. Cardiovascular changes during multiple vertebroplasty with and without vent-hole: an experimental study in sheep. *Spine* 2003;28:1504–12.
14. Porpodis K, Karanikas M, Zarogoulidis P, et al. Fat embolism due to bilateral femur fracture: a case report. *Int J Gen Med* 2012;5:59–63.
15. Wechsler LR. PFO and stroke: what are the data?. *Cardiol Rev* 2008;16:53–7.
16. Mueller F, Pfeifer C, Kinner B, et al. Post-traumatic fulminant paradoxical fat embolism syndrome in conjunction with asymptomatic atrial septal defect: a case report and review of literature. *J Med Case Rep* 2011;5:142–5.
17. Kizer JR, Devereux RB. Patent foramen ovale in young adults with unexplained stroke. *N Engl J Med* 2005;353:2361–72.