


Fatal fat embolism syndrome during posterior spinal fusion surgery

A case report and literature review

Tadatsugu Morimoto, MD, PhD^{a,*} , Takaomi Kobayashi, MD^a, Tomohito Yoshihara, MD, PhD^a, Masatsugu Tsukamoto, MD^a, Keita Kai, MD, PhD^b, Masaaki Mawatari, MD, PhD^a

Abstract

Rationale: Fat embolism syndrome (FES) is a rare but potentially lethal complication. Although serious FES is associated with long bone fractures and major joint surgery, the number of patients who develop fatal FES intraoperatively is probably higher than the described number. We herein report an extremely rare autopsy-confirmed case of fatal FES during posterior spinal fusion to enhance pedicle screw (PS) fixation with allograft bone augmentation.

Patient Concerns: A 74-year-old woman came to the hospital complaining of back pain, lower extremity pain and numbness, and intermittent claudication.

Diagnosis: She was diagnosed with lumbar degenerative scoliosis and lumbar spinal canal stenosis based on imaging findings.

Interventions: During posterior spinal fusion to enhance pedicle screw fixation with allograft bone augmentation, her blood pressure and oxygen saturation dropped significantly, so the operation was stopped, and cardiopulmonary resuscitation was performed. Chest computed tomography demonstrated bilateral diffuse alveolar infiltrates.

Outcomes: The patient died three days later due to fat embolism. The autopsy revealed diffuse myocardial ischemia and diffuse alveolar damage. Numerous fat emboli were observed at lung, kidney and spleen and small necrotic bone fragments, possibly derived from allograft bone debris, were found in the peripheral pulmonary artery.

Lessons: Fatal FES associated to seemingly harmless isolated osteoporotic vertebral fractures-vertebroplasty and posterior spinal fusion has been reported. The mechanism was hypothesized to be that both vertebral fractures and spine surgery have the potential to involve bone marrow, thereby increasing intraosseous pressure, and this pressure dislodges fat and bone marrow and pushes them out into the venous circulation, causing systemic inflammation.

This is the first report to show histological evidence that the allografted bone embolized to the lungs. Although several reports have indicated that inserting reinforcing materials into the tapped screw holes can enhance the pedicle screw fixation, this procedure may cause severe FES due to fat and debris of material augmentation (i.e. cement, hydroxyapatite, allograft bone). It is important for physicians, especially spinal surgeons, and anesthetists, to be aware of the potential for FES to occur during spinal surgery, which can cause serious complications in a small minority of patients.

Abbreviations: FES = fat embolism syndrome, PS = pedicle screw.

Keywords: allograft, bone augmentation, case report, fat embolism syndrome, posterior spinal fusion surgery

Editor: Maya Saranathan.

Written informed consent was obtained from the patient 's next of kin for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

We have confirmed that the person's next of kin has consent for publication.

Availability of data and material: Not applicable as this is a case report.

The authors have no funding and conflicts of interest to disclose.

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

^aDepartment of Orthopaedic Surgery, Faculty of Medicine, Saga University, 5-1-1 Nabeshima, Saga, Japan, ^bDepartment of pathology, Faculty of Medicine, Saga University, 5-1-1 Nabeshima, Saga, Japan.

* Correspondence: Tadatsugu Morimoto, Department of Orthopedic Surgery, Faculty of Medicine, Saga University, Nabeshima 5-1-1, Saga 849-8501, Japan (e-mail: sakiyuki0830@gmail.com).

Copyright © 2021 the Author(s). Published by Wolters Kluwer Health, Inc.

This is an open access article distributed under the Creative Commons Attribution License 4.0 (CCBY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Morimoto T, Kobayashi T, Yoshihara T, Tsukamoto M, Kai K, Mawatari M. Fatal fat embolism syndrome during posterior spinal fusion surgery: a case report and literature review. *Medicine* 2021;100:51(e28381).

Received: 17 November 2021 / Accepted: 2 December 2021

<http://dx.doi.org/10.1097/MD.00000000000028381>



Figure 1. Lumbar X-ray at four days after anterior lumbar interbody fusion. During placement of the L5/S1 interbody fusion cage and iliac screws, followed by the insertion of a pedicle screw with augmented allografted bone, the procedure was interrupted for cardiopulmonary resuscitation due to shock vitals.

1. Introduction

Fat embolism syndrome (FES) is a rare but potentially lethal complication.^[1,2] Although most previously reported cases of serious FES have been associated with long bone fractures and major joint surgery,^[1,2] the number of patients who develop fatal FES intraoperatively is probably higher than the described number. We herein report an extremely autopsy-confirmed rare case of fatal FES during posterior spinal fusion to enhance pedicle screw (PS) fixation with allograft bone augmentation. To our knowledge, this is the first report to show histological evidence that not only fat but also the allografted bone embolized to the lungs.



Figure 2. Computed tomography of the lungs. Chest computed tomography showed bilateral diffuse alveolar infiltrates.

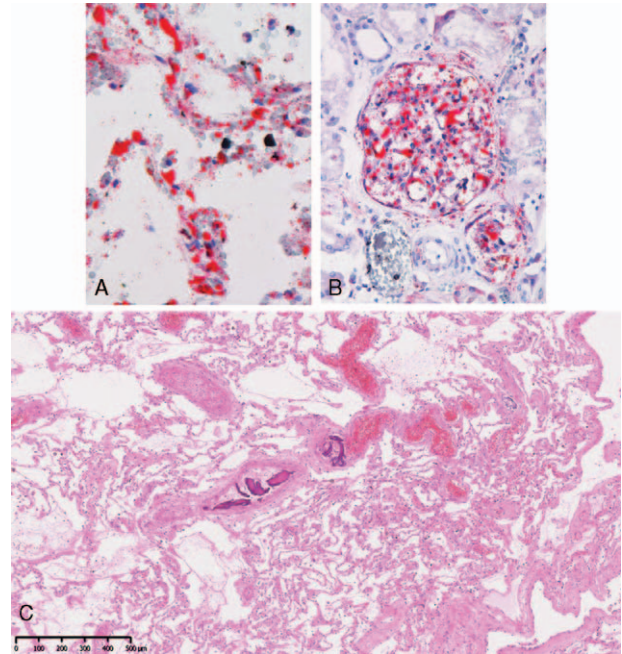


Figure 3. Histological findings. Numerous fat emboli were found at alveolar of the lung (A: Oil-red staining, $\times 400$) and at glomerulus of the kidney (B: Oil-red staining, $\times 200$). (C) Small necrotic bone fragments were found in the peripheral pulmonary artery.

2. Case presentation

A 74-year-old woman with severe back pain and intermittent claudication due to lumbar degenerative scoliosis and spinal canal stenosis. She showed no abnormalities in her physique or on laboratory tests. Retroperitoneal transpoas approach with lateral vertebral body fusion (L2/3-L4/5) was performed first without any intraoperative or postoperative complications. Four days after the initial operation, posterior spinal fusion (L2-iliac) was planned. L5/S1 posterior interbody fusion with a titanium cage and fixation of four iliac screws were performed, followed by PS fixation. Allograft bone was inserted into the screw holes to increase the PS fixation at L2 and L3 (Fig. 1). When L2 and L3 PS were placed, the systolic blood pressure decreased abruptly, and it became difficult to maintain the systolic blood pressure. Following the use of adrenaline, the invasive arterial pressure improved, but the oxygen saturation fell from 98% to 64%. The patient was promptly returned to the supine position, and cardiopulmonary resuscitation was performed, after which the patient was managed on a ventilator. Chest computed tomography demonstrated bilateral diffuse alveolar infiltrates, suspected FES (Fig. 2). Unfortunately, the patient died three days after entering the intensive-care unit.

The autopsy revealed diffuse myocardial infarction and severe diffuse alveolar damage. Numerous fat emboli were observed at lung (Fig. 3A), kidney (Fig. 3B) and spleen. Unusually, small necrotic bone fragments, possibly derived from allograft bone debris, were found in the peripheral pulmonary artery (Fig. 3C). The cause of death was determined to be systemic fat embolism.

3. Discussion

Fatal FES related to seemingly harmless isolated osteoporotic vertebral fractures,^[3,4] vertebroplasty^[5] and posterior spinal

Table 1**Cases of fatal pulmonary fat embolism after or during posterior spinal fusion surgery.**

Authors	Age	Sex	Diagnosis	Operated Level	PS	PS with augmented	Onset of FES	Symptom at onset	Days from onset to death
Gittman ^[7]	17	Female	Scoliosis	T5-L4	Not used	Not used	Immediately after surgery	Shock vitals (hypotension, hypoxia)	POD 10
Brandt ^[8]	56	Female	Spinal stenosis	L4-S1	Used	Not used	6 h after surgery	unconscious	POD 0
Temple ^[9]	61	Female	Spinal infection	T4-L4	Used	Cement	During surgery	Shock vitals (hypotension, hypoxia)	POD 0
Joffe ^[10]	11	Male	Neuromuscular Scoliosis	T4-L3	Used	Not used	During surgery	Shock vitals (hypotension, hypoxia)	POD 0
Stroud ^[11]	17	Female	Neuromuscular Scoliosis	T1-sacrum	Used	Not used	24 h after surgery	sudden cardiac arrest	POD 1
Takahashi ^[12]	57	Male	Spinal infection	T1-T6	Used	Not used	5 h after surgery	suddenly dyspnea	POD 0
Our case	78	Female	Degenerative scoliosis	L2-iliac	Used	Allograft	During surgery	Shock vitals (hypotension, hypoxia)	POD 3

FES = fat embolism syndrome, POD = postoperative day, PS = pedicle screw.

fusion^[6–11] has been reported. The mechanism was hypothesized to be that both vertebral fracture and spinal surgery can involve the bone marrow, which increases the intraosseous pressure; this pressure then dislodges the fat and bone marrow, pushing them out into the venous circulation^[1,5] and causing systematic inflammation.^[1,2] Vertebroplasty is commonly used to treat osteoporotic vertebral fractures, but pulmonary embolism of cement or fat and bone marrow have been documented as serious or fatal complications after vertebroplasty.^[5] Spinal surgeons need to be aware of FES occurring during spinal surgery, which can cause serious complications in a very minority of patients.

To the best of our knowledge, there have been only seven cases of fatal FES occurring after posterior spinal fusion with instrumentation^[6–11] (Table 1). FES can occur intraoperatively and postoperatively. Thus, patients with fluctuating blood pressure and unstable oxygenation during surgery should receive careful observation after surgery. Six of the seven cases received PS with bone cement augmentation (1 case), allograft bone augmentation (our case) and no augmentation (5 case). Embolisms occurring during intramedullary fixation of fracture^[12] and cemented^[13,14] and noncemented total hip arthroplasty^[15] have been well studied by echocardiography. Similarly, in spine surgery, “echogenic material” by echocardiography passing through the right heart has been demonstrated in the several situations, including 1) probing of the vertebral body,^[16] 2) insertion of cement^[17] or hemostatic agents^[18,19] into the PS pilot hole and 3) placement of the PS.^[17,19] In addition, Kuhns et al^[19] provided histological evidence that hemostatic agents embolize to the lungs. Likewise, in the present case, a histological examination of lung tissue sections revealed multiple fat and small necrotic bone fragments, probably derived from the allografted bone.

To our knowledge, this is the first report to show histological evidence that the allografted bone embolized to the lungs. Therefore, although several reports have indicated that inserting reinforcing materials into the tapped screw holes (i.e. cement,^[20] hydroxyapatite,^[21] allograft bone^[22]) can enhance PS fixation, they might also cause severe pulmonary embolism from fat and debris of material augmentation. Spinal surgeons need to be aware of the risk of FES associated with pressurization of the vertebral body during commonly performed spinal trauma and surgical procedures.

There were several possible risk factors for FES, such as multilevel spinal surgery, impaired cardiopulmonary function, obesity, and osteoporosis.^[18,19]

However, there is no specific treatment for FES besides ventilation management. Limiting the increase in intraosseous pressure during long bone surgery may reduce the incidence of FES.^[23] In spinal procedures, using the vertebral pulsed jet lavage technique to remove bone marrow from the vertebral body prior to cement injection has been reported to reduce the increased intraosseous pressure,^[24,25] but this remains to be verified.

FES is relatively uncommon and subclinical in most patients, and its risk factors and treatments are still unknown. Large-scale clinical studies are needed to identify patients at high risk and determine the appropriate treatments for FES.

Acknowledgments

The authors thank Prof. Y. Sakaguchi (Department of Anesthesiology, Faculty of Medicine, Saga University) for his cooperation in suggesting skilled surgical anesthesia findings and Prof. S. Kimura and Dr. M. Yoshimura (Department of hematology, Faculty of Medicine, Saga University) for their helpful discussions.

Author contributions

Conceptualization: Tadatsugu Morimoto, Takaomi Kobayashi, Masaaki Mawatari.

Data curation: Tomohito Yoshihara, Masatsugu Tsukamoto.

Formal analysis: Takaomi Kobayashi, Tomohito Yoshihara.

Funding acquisition: Tadatsugu Morimoto.

Investigation: Tadatsugu Morimoto, Takaomi Kobayashi, Keita Kai.

Methodology: Tadatsugu Morimoto.

Project administration: Tadatsugu Morimoto.

Resources: Tadatsugu Morimoto.

Software: Takaomi Kobayashi.

Supervision: Masaaki Mawatari.

Validation: Tadatsugu Morimoto, Masaaki Mawatari.

Visualization: Tadatsugu Morimoto.

Writing – original draft: Tadatsugu Morimoto.

Writing – review & editing: Masatsugu Tsukamoto, Masaaki Mawatari.

References

- [1] Weinhouse GL. Fat embolism syndrome. In: UpToDate, 2021. [uptodate.com/contents/fat-embolism-syndrome](https://www.uptodate.com/contents/fat-embolism-syndrome).
- [2] Stein PD, Yaekoub AY, Matta F, Kleerekoper M. Fat embolism syndrome. *Am J Med Sci* 2008;336:472–7.

- [3] Lastra RR, Saldanha V, Balasubramanian M, Handal J. Fatal fat embolism in isolated vertebral compression fracture. *Eur Spine J* 2010;19 (Suppl 2):S200–2.
- [4] Tyagi A, Aggarwal R, Soni KD, Trikha A. Prone positioning for management of fat embolism syndrome in a patient with spine fracture; an unusual scenario and review of literature. *Bull Emerg Trauma* 2019;7:192–5.
- [5] Syed MI, Jan S, Patel NA, Shaikh A, Marsh RA, Stewart RV. Fatal fat embolism after vertebroplasty: identification of the high-risk patient. *AJNR Am J Neuroradiol* 2006;27:343–5.
- [6] Gittman JE, Buchanan TA, Fisher BJ, Bergeson PS, Palmer PE. Fatal fat embolism after spinal fusion for scoliosis. *JAMA* 1983;249:779–81.
- [7] Brandt SE, Zeegers WS, Ceelen TL. Fatal pulmonary fat embolism after dorsal spinal fusion. *Eur Spine J* 1998;7:426–8.
- [8] Temple JD, Ludwig SC, Ross WK, Marshall WK, Larsen L, Gelb DE. Catastrophic fat embolism following augmentation of pedicle screws with bone cement: a case report. *J Bone Joint Surg Am* 2002;84:639–42.
- [9] Joffe D, Elrefai A, Thomas M. Fatal marrow emboli in a pediatric patient having posterior spinal instrumentation for scoliosis repair. *Paediatr Anaesth* 2006;16:89–91.
- [10] Stroud MH, McCarthy RE, Parham DM, Schexnayder SM. Fatal pulmonary fat embolism following spinal fusion surgery. *Pediatr Crit Care Med* 2006;7:263–6.
- [11] Takahashi S, Kitagawa H, Ishii T. Intraoperative pulmonary embolism during spinal instrumentation surgery. A prospective study using transoesophageal echocardiography. *J Bone Joint Surg Br* 2003;85: 90–4.
- [12] Pell AC, Hughes D, Keating J, Christie J, Busuttill A, Sutherland GR. Brief report: fulminating fat embolism syndrome caused by paradoxical embolism through a patent foramen ovale. *N Engl J Med* 1993;329: 926–9.
- [13] Ereth MH, Weber JG, Abel MD, et al. Cemented versus noncemented total hip arthroplasty—embolism, hemodynamics, and intrapulmonary shunting. *Mayo Clin Proc* 1992;67:1066–74.
- [14] Urban MK, Sheppard R, Gordon MA, Urquhart BL. Right ventricular function during revision total hip arthroplasty. *Anesth Analg* 1996;82:1225–9.
- [15] Hagio K, Sugano N, Takashina M, Nishii T, Yoshikawa H, Ochi T. Embolic events during total hip arthroplasty: an echocardiographic study. *J Arthroplasty* 2003;18:186–92.
- [16] Takahashi Y, Narusawa K, Shimizu K, Takata M, Nakamura T. Fatal pulmonary fat embolism after posterior spinal fusion surgery. *J Orthop Sci* 2006;11:217–20.
- [17] Aebli N, Krebs J, Davis G, Walton M, Williams MJ, Theis JC. Fat embolism and acute hypotension during vertebroplasty: an experimental study in sheep. *Spine (Phila Pa 1976)* 2002;27:460–6.
- [18] Duplantier NL, Couch M, Emory L, Zavatsky JM. Cardiac emboli documented by intraoperative transoesophageal echocardiogram during administration of a topical hemostatic agent prior to pedicle subtraction osteotomy. *Spine (Phila Pa 1976)* 2016;41:E556–60.
- [19] Kuhns CA, Cook CR, Dodam JR, et al. Injectable gelatin used as hemostatic agent to stop pedicle bleeding in long deformity surgical procedures: does it embolize? *Spine (Phila Pa 1976)* 2015;40:218–23.
- [20] Becker S, Chavanne A, Spitaler R, et al. Assessment of different screw augmentation techniques and screw designs in osteoporotic spines. *Eur Spine J* 2008;17:1462–9.
- [21] Kanno H, Aizawa T, Hashimoto K, Itoi E. Enhancing percutaneous pedicle screw fixation with hydroxyapatite granules: a biomechanical study using an osteoporotic bone model. *PLoS One* 2019;14:e0223106.
- [22] Lee GW, Yeom JS, Kim HJ, Suh BG. A therapeutic efficacy of the transpedicular intracorporeal bone graft with short-segmental posterior instrumentation in osteonecrosis of vertebral body: a minimum 5-year follow-up study. *Spine (Phila Pa 1976)* 2013;38:E244–50.
- [23] Pitto RP, Hamer H, Fabiani R, Radespiel-Troeger M, Koessler M. Prophylaxis against fat and bone-marrow embolism during total hip arthroplasty reduces the incidence of postoperative deep-vein thrombosis: a controlled, randomized clinical trial. *J Bone Joint Surg Am* 2002;84:39–48.
- [24] Benneker LM, Krebs J, Boner V, et al. Cardiovascular changes after PMMA vertebroplasty in sheep: the effect of bone marrow removal using pulsed jet-lavage. *Eur Spine J* 2010;19:1913–20.
- [25] Hoppe S, Elfky T, Keel MJ, Aghayev E, Ecker TM, Benneker LM. Lavage prior to vertebral augmentation reduces the risk for cement leakage. *Eur Spine J* 2016;25:3463–9.