

# Novel posterior technique to temporize life-threatening hemorrhage after great vessel laceration during posterior osteotomy

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## Abstract

**Purpose** Great vessel injury during posterior 3-column osteotomy is rare, but potentially fatal. Literature review revealed limited data guiding spine surgeons during this major catastrophe. In this study our aim was first, to present our case of mortality; second, to discuss a novel technique that can be performed to temporize hemorrhage in a life-threatening situation where an iatrogenic great vessel injury occurs and hemodynamic stability cannot be achieved through usual means of hemostasis; third, a cadaveric study to determine if this novel technique is feasible.

**Methods** Three fresh cadavers including thoracic, lumbar, and pelvis were used. A thoraco-abdominal approach was used to access great vessels at the level of L3. The aorta and vena cava were identified and tagged. The cadavers were turned prone; a pedicle subtraction osteotomy was performed at the level of L3. A novel posterior peri-vertebral approach was used to reach the great vessels. The aorta and vena cava were occluded digitally with this approach and success confirmed visually through the thoraco-

abdominal incision. Timing of the procedure and structures at risk were recorded.

**Results** In all three cadavers, we were able to successfully occlude the great vessels from a prone position. The average amount of time it took to digitally occlude the great vessels was less than a minute. Structures at risk included the L1 and L2 nerve roots, lumbosacral plexus, and the sympathetic trunk.

**Conclusions** The posterior peri-vertebral approach can potentially be used by a spine surgeon during a life-threatening situation to temporarily occlude great vessel hemorrhage while waiting for the assistance of a vascular/trauma team.

**Keywords** Digital occlusion · Intraoperative great vessel injury · Pedicle subtraction osteotomy · Intraoperative aortic laceration · Intraoperative inferior vena cava laceration

## Introduction

Vascular injury is an uncommon, but not rare, complication of spine surgery. There have been numerous reports of single or multiple cases of vascular injuries occurring during spinal surgery with the incidence ranging from 0.03 to 0.17 % [1]. Injuries may occur to the abdominal aorta, inferior vena cava, common, internal and external iliac arteries, and veins. Risk factors for iatrogenic vascular injury during a spine surgery in the prone position include the following: defects in the anterior longitudinal ligament and anterior aspect of the annulus fibrosus, degenerative disc disease, adhesions caused by previous discectomy or abdominal surgical procedure, retroperitoneal inflammatory processes, and vascular disease [2–5]. Increased intra-

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abdominal pressure in the prone position may force retroperitoneal vessels closer to the anterior aspect of the spine where they may be more easily injured. To minimize the risk of a vascular injury, careful positioning with a suspended abdomen in a pressure-free frame, meticulous surgical technique, and limited depth of instrument placement are essential [6]. Vascular injury during posterior instrumentation of the spine occurs in less than one of every 2000 operations [5]. Laceration of the aorta or inferior vena cava carries mortality rates as high as 61 and 78 %, respectively [7, 8]. The consequences of vascular injuries may be quite devastating; therefore, knowledge of the surgical options for emergent treatment is essential to avert death.

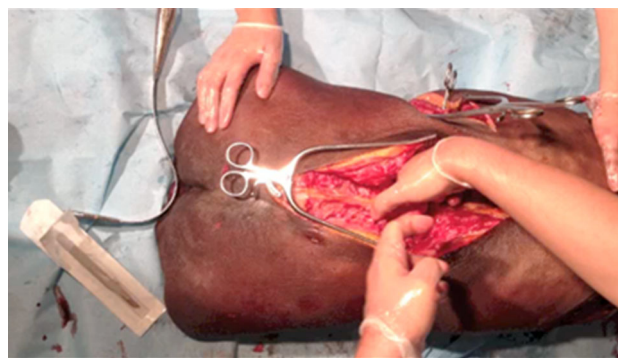
This study began after a mortality at our institution which occurred during a pedicle subtraction osteotomy. A 58-year-old female patient presented with congenital scoliosis with hemi-vertebrae, and a flat-back deformity from multiple front and back fusions. The patient was morbidly obese with a body mass index of 51. We performed an asymmetrical pedicle subtraction osteotomy (PSO) for bi-plane corrections. While pushing the posterior vertebral body wall forward during the last step of the osteotomy, there was a sudden drop in blood pressure. There was no evidence of pulsatile bleeding; however, the patient became increasingly unstable. The wound was packed and temporarily closed, the patient was turned to the supine position, and CPR and emergency fluid and blood resuscitation were initiated. An exploratory laparotomy was performed by the trauma surgeons but the patient died within 25 min with an inability to control bleeding. An autopsy was performed and a laceration of the inferior vena cava was identified.

This incident prompted us to explore means to temporarily control hemorrhage from a vascular injury during this type of life-threatening situation when: (1) the patient cannot be adequately resuscitated; (2) the patient is prone during a PSO or vertebral column resection (VCR); and (3) vascular/trauma surgeons are not readily available.

## Methods

Three fresh cadavers including thoracic, lumbar, and pelvis were thawed. A thoraco-abdominal approach was used to access great vessels at the level of L3. The aorta and vena cava were identified and tagged.

The cadavers were then turned prone. An open exposure was made from T12 to L5; a pedicle subtraction osteotomy (PSO) was performed at the level of L3. To obtain digital control of the aorta and IVC, we then developed a plane circumferentially and periosteally on the vertebral body of L3 by placing a finger between the vertebral body and the



**Fig. 1** Posterior approach for digital occlusion

psoas muscle (Fig. 1). Once we were able to palpate and compress the great vessels between our fingers, we then turned the cadaver to a lateral decubitus position to confirm the compression of the vessels through our previously dissected retroperitoneal approach (Fig. 2).

Potential vital structures at risk were identified and recorded. The amount of time to perform the posterior peri-vertebral digital occlusion of the great vessels after the completion of the PSO to digital occlusion was recorded. (This was measured from time of final bony cut to digital occlusion.)

## Results

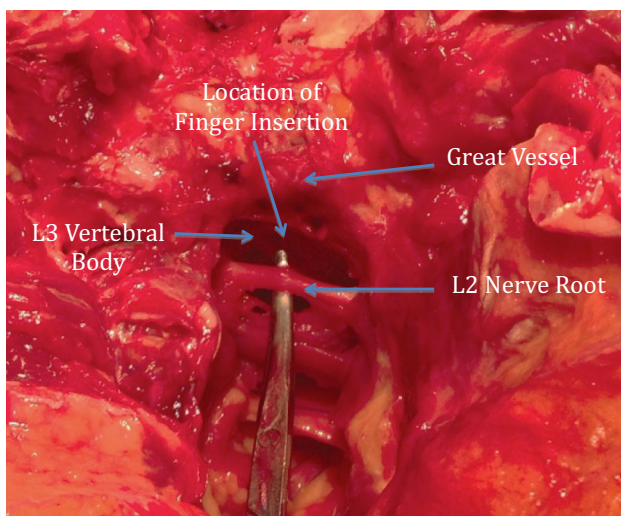
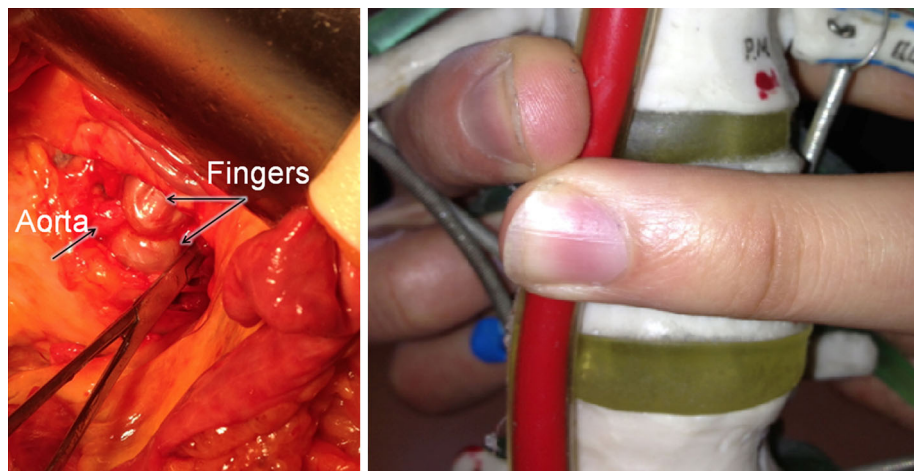
In all three cadavers, we were able to successfully occlude the great vessels from a prone position and confirm compression through our retroperitoneal exposure. The average amount of time it took to digitally occlude the great vessels was less than a minute. The structures at risk at the level of L3 included (starting posteriorly): L1 and L2 nerve roots, psoas muscle, lumbosacral plexus, and sympathetic trunk, which were all lateral to the finger dissection (Fig. 3).

## Discussion

Vascular injuries during spinal surgery occur due to the proximity of the vasculature to the vertebral bodies and result from retraction or dissection. Iatrogenic injuries of the lower abdominal aorta and iliac vessels during spinal surgery were first reported by Linton and White [9].

There are few reports of interventions used acutely to treat an aortic injury complicating spinal surgery. Minor et al. [10] reported a case of a misplaced pedicle screw at T5 which was repaired electively with a thoracic endograft. Another report in 2011 first described endovascular repair of a thoracic aortic injury intra-operatively during a reconstructive posterior spinal surgery [11]. A vertebral

**Fig. 2** Retroperitoneal view of digital occlusion through posterior approach in cadaver (left) and model (right)



**Fig. 3** Structures at risk through posterior approach: nerve roots one and two levels above the osteotomy, lumbosacral plexus, and sympathetic trunk

column resection was being performed when the aorta was lacerated. The femoral artery was accessed for the endograft procedure.

Another case report by Loh et al. [8] describes an aortic perforation during vertebrectomy at T11. The wound cavity was tightly packed and the patient placed supine for angiography and stent graft placement. There has been a case series reported by Kopp et al. [12] which has five patients who had aortic injuries with acute hemorrhage. However, only one of the five occurred during reconstructive spine surgery and placement of a cage when acute hemorrhage was seen. The authors were able to ligate a part of the aorta and await vascular surgery, but the details were lacking.

While severe vascular injuries remain uncommon during posterior spinal surgery, early control of hemorrhage can provide time for appropriate definitive management. Our current anatomic study demonstrates that an orthopedic

surgeon can quickly (within a minute) gain temporary control of the great vessels while the patient is still in a prone position. This may stabilize the patient and provide the necessary time to wait for definitive repair by the ancillary trauma and/or vascular team. This technique may theoretically be more applicable to arterial rather than venous injury. But during a critical life-threatening hemorrhage, it may be difficult to determine which one of the great vessels is truly injured. Therefore, potential digital occlusion of both vessels may be necessary.

The position of the patient for definitive management is a critical step. During our experiment we occluded the vessels in a prone position, and then turned the cadaver to a semi-lateral decubitus position while keeping constant digital pressure on the great vessels. This position will allow the vascular surgeons to perform an angiogram with stent placement or an open anterior approach to the aorta and/or vena cava for direct repair.

The limitations to this cadaveric study included not being able to use a full-size human with bilateral lower extremities to turn and the inability to evaluate occlusion in a flowing model.

In conclusion, the posterior peri-vertebral approach can potentially be used during a life-threatening emergency situation to temporarily control great vessel bleeding during posterior spine surgery.

**Conflict of interest** The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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