Haemostasis in Spinal Surgery

a report by
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Blood loss is an inherent risk in surgery, and the control of haemostasis is essential in spinal surgery. These procedures, in which minor and major blood vessels are often mobilised, present risks of bleeding, and even minute bleeds can cause neurological damage to the patient. However, spinal surgeries are necessary in treating various disorders, including disc herniations, cervical or lumbar spinal stenosis, tumours, infections or unstable spinal fractures. In degenerative disc disease, degenerative spondylolisthesis or degenerative 3D scoliosis with spinal deformities, patients often suffer pain caused by abnormal or increased motion at an unstable vertebral segment. Some patients experience progressive narrowing of the spinal canal or are neurologically affected to yield sensorimotor deficits. When available indicated non-surgical treatments have been exhausted, a common option for these patients is to undergo spinal fusion, in which two or more vertebrae are joined together using autografts, allografts or synthetic bone graft substitutes.

Three commonly performed fusion surgeries are the anterior (ALIF), posterior (PLIF) and transforaminal (TLIF) lumbar interbody fusions. ALIF procedures approach the spine through a mid-line, antero-lateral or far-lateral pathway, crossing the abdominal muscles bluntly and mobilising the peritoneal sack. In the majority of cases, retroperitoneal approaches are chosen. After retraction of the abdominal muscles and peritoneum and, if necessary, mobilisation of the blood vessels, the spine is exposed, allowing for removal of the disc space, preparation of the graft bed and graft insertion. In PLIF procedures, the spine is accessed through an incision in the patient’s back. Partial removal of yellow ligament and corresponding cranial hemilamina provides visibility and accessibility to the ipsilateral nerve roots and entry into the spinal canal. With protection of the cranial nerve root and by medialising the dura and caudal nerve root, the affected disc space is exposed and can be prepared for graft implantation as in ALIF procedures. TLIF differs from ALIF as it uses a midline or paramedian incision in the patient’s back and the graft is inserted transfaraminally. This article examines the role of haemostasis in spinal surgery, with specific focus on ALIF and PLIF techniques and microsurgeries, and expresses personal opinions of haemostatic agents.

Minimally Invasive Techniques

Though hailed as a minimally invasive alternative, laparoscopic spinal fusion is not a commonly performed spinal surgery in Europe for a number of reasons. A prerequisite for laparoscopy is a pre-formed cavity, which does not typically exist in ALIF cases. Furthermore, during laparoscopy, visibility of the adjacent areas is limited. Alternative options to the 8–12cm incisions in the open ALIF and PLIF procedures are mini-open, microscope-assisted surgeries. Mini-open ALIF techniques have smaller incisions of approximately 3–4cm and, like the macro-open techniques, have the advantage of providing good anatomical visibility (see Figure 1). Furthermore, any complication encountered during a mini-open procedure only requires expansion of the incision, whereas a laparoscopy would have to be completely revised. In ALIF procedures, microscope assistance is not routinely performed, although certain critical intra-operative steps may help to avoid complications such as vessel lacerations. The use of a microscope in PLIF procedures is a standard in our hospital, but used only when critical, whereas we always perform microscope-assisted PLIF (see Figure 2). Microsurgery has been confirmed to reduce incision size, intra-operative blood loss and morbidity in intra-spinal surgical interventions. The control of intra-operative bleeding in microsurgery has been demonstrated in our own experiences in comparing macrosurgical with microsurgical interventions, where the amount of bleeding and scar tissue formed is directly related to the extent of exposure.

Risks of Bleeding

Like any other surgery, there are inherent risks posed by intra-operative bleeding in spinal fusion. In the ALIF procedure, the main cause of bleeding is from direct laceration to the segmental vessels, the ascending lumbar vein and the left common iliac vein. Injuries to large vessels such as the aorta and vena cava are rare. Vascular injury affects between 1 and 16% of ALIF cases. The average blood loss is 600ml, greater than the average range of 200–300ml in mini-open approaches. Bleeding in PLIF procedures originates mainly from the paravertebral muscle, the epidural veins and the basivertebral vein. A surgeon encounters the epidural veins in the spinal canal, which often increase in number and size as the surgeon progresses further up the lumbar spine. Epidural vein bleeds are common, but easily resolved by haemostatic measures. Although 58% of microscopic decompression surgeries from the posterior approach have been shown to develop haematomata, these usually have no clinical relevance. Standard intra-operative blood loss in the traditional open PLIF averages approximately 740ml per segment, although the blood loss in the microsurgical approach is significantly lower, averaging 175ml per segment (p<0.001).

Generally, the worse a laceration is and the larger the vessel, the greater and more detrimental the blood loss. However, injury to major vessels is extremely rare in posterior approaches, and even in anterior procedures the risk is low with an experienced surgical team.
Surgical Haemostasis

The Importance of Haemostasis

Intra-operative bleeding poses problems to both the surgeon and the patient. Blood obstructs the surgeon’s view and may cause oversight of target pathologies. Any unplanned additional tissue damage due to unexpected bleeding can prolong surgery and decrease its effectiveness, causing fatigue and stress to the surgical team. There are also anaesthesiological risks to the patient due to destabilisation of vital parameters. Intra-operative bleeding also increases the chance of infection and scar tissue formation, thus creating a peridural fibrosis with ingrowth of fibrous connective tissue; the risk of revision surgery is also increased, for example to remove the compression-induced haematomas that may have formed. A decrease in post-operative haemoglobin and haematocrit levels is linked to the degree of intra-operative bleeds, and can reduce a patient’s capacity to transport oxygen. Depending on the amount of blood lost, the patient may experience a range of symptoms, including weakness, fatigue, hypotension, dyspnoea and tachycardia. If blood loss is extensive, blood transfusions become necessary, posing health risks to the patient and financial burdens on the healthcare system. In short, intra-operative bleeding negatively affects patient outcome and can lengthen recovery time.

Blood loss in spinal surgery, as in any kind of surgery, must be carefully monitored and minimised to reduce the risk to the patient. This is achieved by haemostasis through a variety of situation-dependent methods. The more traditional haemostatic methods of clamps, sutures and electrocautery can be used for direct cessation of openly bleeding vessels. Bleeding from hard tissue originates from intra-osseous vessels and cavities, which bleed when they are operated on with chisels and punches. Such bleeds can be treated with bone wax, although the high temperatures caused by high-speed drills without irrigation can also seal cavities and vessels. Soft tissues and muscles often bleed profusely with no clear source. In these cases, cautery or chemical haemostatic agents are helpful. Clamps, cautery and suture ligation are commonly used in the ALIF procedure, while cautery is favoured in PLIF for intra-spinal work. Haemostasis is generally easier to control in larger-scale surgeries; in microsurgeries, chemical haemostatic agents have played an increasingly important role. Although haemostasis can theoretically be compromised by coagulopathies, these methods remain applicable to patients with inherent or induced bleeding disorders. It is the responsibility of the physician to use the patient’s medical history to preempt any intra-operative bleeding complications and administer agents accordingly against heparin, coagulants or other medications. The meticulous application of haemostatic adjuncts, whether traditional or chemical, has demonstrated great utility in controlling intra-operative blood loss and, in doing so, reducing a number of bleeding-related risks.

Controlling Haemostasis

Intra-operative bleeding can be mitigated by the use of hypotensive anaesthesia and the positioning of the patient, although haemostatic techniques will still be needed. Available chemical haemostatic agents include oxidised cellulose, absorbable gelatine sponges, microfibril collagen, saccharose and thrombin. These products vary in efficacy and their utility is sometimes limited by aggressively bleeding sites and difficulties in application. Thrombin is a critical plasma protein in coagulation, activated by the intrinsic and extrinsic pathways, with the ability to bypass the initial enzymatic steps of the coagulation pathway. Not only can it cleave fibrinogen to form a fibrin gel, it can also directly activate the aggregation and adhesion of platelets to a wound. For these reasons, thrombin has been purified and used in topical control of haemostasis for more than 60 years.11

Gelfoam® (Pfizer) is an absorbable gelatine sponge that has been used in spinal surgery for more than 50 years, although its haemostatic properties are not fully understood. Prepared from porcine skin gelatine, the water-insoluble sponge is highly absorbent and resorbed into soft tissues within four to six weeks without forming excessive scar tissue. Though useable on its own as a haemostatic device, many spinal surgeries frequently opt to use Gelfoam soaked in thrombin as a topical haemostatic agent.13

A fairly new topical haemostatic agent is FloSeal™ (Baxter Healthcare), a matrix of cross-linked bovine-derived gelatine and topical human thrombin. Where fibrin sealants require application to a relatively dry surface, FloSeal must be applied to actively bleeding sites due to its unique mechanism of action, upon which the gelatine granules swell and conform to the shape of the wound site, restricting blood flow by a tamponade effect. The blood is then exposed to high concentrations of thrombin at the surface of the gelatine granules, providing a stable base for the fibrin clot to form around. The gelatine granules in the clot are resorbed into the body as the wound heals. Although the human thrombin component has the potential to induce allergic responses, this has not been observed in clinical trials.13

In a multicentre clinical study, 127 patients undergoing discectomies, fusions and decompression surgeries were randomised to the experimental haemostatic treatment of FloSeal or the control treatment of...
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...agents that we use in the hospital, we have found FloSeal to be the most... 5. Kozak JA, Heilman AE, O'Brien JP, Anterior lumbar interbody...Gelfoam–thrombin.14 In spite of the treatment group exhibiting more...Preparation and application are quick and easy: generally, the product can...FloSeal stops bleeds more quickly and effectively than the other mentioned...Regardless of the haemostatic agent used, the most important element in...Concomitant with the growing use of microsurgical techniques is the ever...Conclusion

The method of haemostatic control depends largely on circumstance and the source of blood loss. For larger surgeries, it is not always necessary to go beyond the traditional techniques of clamping, cautery and suture ligation, although topical haemostatic agents are useful adjuncts. There is a growing tendency towards microsurgical techniques in spinal surgery because of the multiple benefits, including reduced intra-operative bleeding, thus resulting in an enhanced patient outcome. In ALIF procedures, where macroscopic and mini-open techniques are sufficient, chemical haemostatic agents are rarely used, although they represent an important adjunct. Concomitant with the growing use of microsurgical techniques is the ever-increasingly important role of haemostatic agents, as seen in the common use in microsurgically assisted PLIF.

Regardless of the haemostatic agent used, the most important element in controlling blood loss is patience to ensure that complete haemostasis is achieved to obtain the best possible outcome. Surgeons will invariably have their reasons for selecting one haemostatic agent over another, be it personal preference or type of surgery and the musculature and tissues involved. Ultimately, the efficacy and safety of the haemostatic agent should be weighted with regards to the benefits presented to the patient. ■

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- Proven to control bleeding from oozing to pulsatile flow²
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