Bleeding Scenarios in Spine Surgeries: Role for Topical Hemostatic Agents

Sandeep Sewlikar, Reshmi Pillai, Nilesh Mahajan, Anish Desai

ABSTRACT

Bleeding and bleeding management both pose severe challenges to the surgeon and patients especially in complex surgeries, like spinal surgery. This paper evaluates clinical evidences published on use of topical absorbable hemostats in different bleeding scenarios in spinal surgery. Review of clinical evidence indicates clearly the need for further studies in this space.

Keywords: Fibrin sealant, Hemostatic agents, Oxidized regenerated cellulose, Spine surgery.


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Conflict of interest: None

INTRODUCTION

The perioperative bleeding complication is one of most important factors for increasing the morbidity and mortality. A significant blood loss may result into postoperative complications, such as coagulopathy, disseminated intravascular coagulation (DIC), resulting into hematoma and neurological complication and higher risk of infection. The problems linked to blood loss and blood-sparing techniques in spine surgery have been less studied as compared to other procedures. The blood loss is considered as one of the major challenges in spine surgery. Additionally, other factors, such as aging population and associated comorbidities (coronary artery disease, diabetes, etc.) have increased the risk of perioperative bleeding. As spinal procedures are on the rise, limited literature available in public domain highlighting the perioperative blood loss in spinal surgeries. As compared to pediatric population, osteotomies in adult patients may have high chance of bleeding due to stiffer spines. Hu S has done the systematic review and found that blood loss varies from 1 to 3 liters in adult deformity surgeries, with higher level of fusion required for posterior procedures and greater blood loss when osteotomies through prior fusions are performed, ranging from 325 to 4,700 ml for anterior instrumented procedures. Elgafy H et al in their systematic reviews have referred six studies characterizes blood loss and blood transfusion during major spinal fusion surgeries in patients who did not receive the preventative measures to reduce hemorrhage. The case control study conducted by Frank SM, et al showed that blood loss of 1,800 ml in control group against the comparator electrocautery (Table 1).

In addition to blood loss and related complications, the blood transfusion may also be associated with increased risk of infection, increased length of hospital stay and increased the cost of treatment to the patients. Hence, it is very critical to achieve hemostasis in spinal surgeries to prevent further complications, such as spinal epidural hematoma. Better visualization of the surgical field is very important in spinal surgeries as it encompasses major and extremely delicate neurological structures. Even few milliliter blood losses during spinal surgeries could have a significant impact on the surgical outcome and may lead to devastating neurological damage. The bleeding challenges could be encountered during most of the spinal surgeries, such as cervical

Table 1: Spinal fusion surgeries: blood loss and blood transfusion

<table>
<thead>
<tr>
<th>Authors</th>
<th>Blood loss-ml</th>
<th>Total transfusions, n/N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lentschener C et al</td>
<td>2839</td>
<td>30/37 (81)</td>
</tr>
<tr>
<td>Zheng F et al</td>
<td>1085</td>
<td>70/112 (63)</td>
</tr>
<tr>
<td>Garcia-Erce JA et al</td>
<td>NA</td>
<td>366/556 (66)</td>
</tr>
<tr>
<td>Cha et al</td>
<td>2026</td>
<td>45/52 (87) (with instrumentation)</td>
</tr>
<tr>
<td></td>
<td>1041</td>
<td>36/52 (69) (without instrumentation)</td>
</tr>
<tr>
<td>Wong J et al</td>
<td>2138</td>
<td>Intraoperative—21 of 74 (28)</td>
</tr>
<tr>
<td>Postoperative—10 of 74 (13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gause P et al</td>
<td>766</td>
<td>36/47 (77)</td>
</tr>
<tr>
<td>Reitman C et al</td>
<td>650</td>
<td>23/46 (50)</td>
</tr>
<tr>
<td>Frank SM et al</td>
<td>1800</td>
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</tbody>
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Manager (Clinical Affairs), Senior Executive (Medical Affairs) Manager (Clinical Trial and Device Safety) Director (Medical Affairs Clinical Operations and Device Safety)

Medical Affairs, Clinical Operations and Medical Safety
Johnson and Johnson Ltd., Mumbai, Maharashtra, India

Corresponding Author: Anish Desai, Director, (Medical Affairs, Clinical Operations and Device Safety) Johnson and Johnson Ltd., 501, Arena Space, Off Jogeshwari-Vikroli, Link Road, Jogeshwari (East), Mumbai-400080, Maharashtra, India e-mail: adesai8@its.jnj.com
discectomy, laminectomy/laminoplasty, spine fusion surgeries, deformity surgeries, tumor resection, degenerative spine surgeries, nerve root decompression, etc. With anatomical constraints of surgical space during these kinds of surgeries, it is very critical to focus on the venous framework of the spine, such as Batson’s plexus and epidural venous plexus to minimize the blood loss during spinal surgeries to avoid iatrogenic damage. As discussed by Szpalski M et al., blood sparing techniques can be divided into two categories based on their goals to achieve hemostasis/reduce bleeding or to reduce need for homologous blood transfusion. Various hemodynamic techniques as well as systemic and local drugs/agents, can be used separately or in combination to achieve hemostasis. The commonly used methods, such as mechanical methods and cautery are not viable in spinal surgeries. Mechanical methods, such as direct pressure or ligature, are not practical in spinal surgeries due to essential structures in the region. Although having advantages of precise coagulation of small vessels and less lateral thermal spread compared to monopolar cautery, bipolar cautery may cause occlusion of vessel affecting perfusion of distal neural tissues. Moreover, it is considered not effective in controlling the diffuse capillary bleeding. Hence, use of chemical or biological agents could be a possible option for surgeons to control perioperative bleeding. This could be divided into two groups: systemic (e.g. desmopressin, aprotinin, tranexamic acid, epsilon-aminocaproic acid, estrogens, etc.) and local hemostatic agents (e.g. bone wax, gelatin, collagen, cellulose, fibrin sealants, etc.).

In this article, we have reviewed the various commonly used topical hemostatic agents to achieve effective hemostasis and various bleeding scenarios which could be encountered during neurospinal surgeries.

There are two vertebral venous plexuses—internal and external. Internal vertebral venous plexuses (anterior and posterior) lie within the vertebral canal between the dura mater and the vertebrae, i.e. epidural space. External vertebral venous plexuses are present on anterior and posterior side of the vertebra.

Local hemostatic agents can be used in all types of spinal surgeries to achieve venous hemostasis. Vertebral venous plexus bleeding could be better controlled by local hemostatic agents. The iatrogenic damage to vascular structures in spinal region may lead to diffuse bleeding. In spite of all preoperative measures to control the bleeding chances during surgeries, this is still high possibility to bleeding from epidural venous plexus and diffuse bleeding from other vascular structures. The preference for hemostatic agents would be dependent upon the type and site of the bleeding (Table 2).

### Table 2: Venous plexus and preferable topical hemostatic agents

<table>
<thead>
<tr>
<th>Venous plexus</th>
<th>Preferable hemostatic agents</th>
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</thead>
<tbody>
<tr>
<td>Anterior and posterior internal vertebral plexus</td>
<td>Oxidized regenerated cellulose</td>
</tr>
<tr>
<td>Posterior external vertebral plexus</td>
<td>Oxidized regenerated cellulose</td>
</tr>
<tr>
<td>Anterior external vertebral plexus</td>
<td>Fibrin sealant, oxidized regenerated cellulose</td>
</tr>
<tr>
<td>Epidural venous plexus</td>
<td>Flowable gelatins, fibrin sealant oxidized regenerated cellulose</td>
</tr>
<tr>
<td>Bone-lamina</td>
<td>Bone wax, gelatin foam, oxidized regenerated cellulose</td>
</tr>
</tbody>
</table>

### MECHANICAL

Mechanical methods of hemostasis, such as direct pressure and ligature, are least or not preferred in neurospinal procedures due to bony confinement, depth of surgery and the indispensability of structures.

### THERMAL

Thermal methods (bipolar coagulation) used for arterial bleeding. It may be preference of choice for subcutaneous and identifiable bleeding but would not effective against the diffuse or capillary bleeding. Considering bony confinement and the venous structures in spinal region, such as intraspinal and intraforaminal plexus of veins, bipolar or microcoagulation would not be a feasible option as it may lead to lateral thermal damage to adjacent neural structures and nerve roots. Additionally, it is not very effective against parenchymal or diffuse hemorrhagic oozing. The high risk of occlusion of vessels and subsequent compromise on tissue perfusion due to bipolar coagulation lead to preference for chemical hemostatic agents to control bleeding during intraspinal procedures because of ease of use and effective in diffuse and inaccessible bleeding.

### CHEMICAL: BONE WAX AND GELATING POWDER

Use of bone wax is limited to oozing from bony surfaces, which carries risk of bleeding during spinal procedures, such as laminectomy or screw placement. However, bone wax cannot be molded to contour of the bleeding areas. Hence, absorbable gelatin powder could be used on to the oozing from irregular bony surfaces. Gelatin-based product also has clinical value in as hemostasis in spine surgeries. Gelatin foam sponge is commonly used to fill the cavity of a laminectomy in a bloody field. However, excess gelatin should be removed to avoid adverse effect on bone healing and should be avoided in infected cases. Flowable gelatins achieved the hemostasis in spinal surgeries (discectomy with fusion, decompression surgery).
The risk of bleeding is highest during the epidural phase of the spinal surgeries (e.g. dissecting dura from the lamina), leading to epidural venous oozing. Use of bipolar cautery has limited success due to risk of lateral thermal spread and subsequent injury to vital neural structures. Gelatin-based products also not found to be useful as it easily get dislodged from the bleeding site. In such cases, oxidized regenerated cellulose (ORCs) can be used for hemostasis. It can be cut into small pieces as per the requirement and well conformed to the bleeding surfaces. If required, it can be cauterized for more effective hemostasis. During dural closure, ORCs can be used to prevent cerebrospinal fluid (CSF) or dural leaks.

During laminectomy for spinal tumor surgery, extradural hemorrhage could be encountered post retraction posterior arch flap. Hence, it would be critical to achieve extradural hemostasis and this could be achieved by application of ORCs followed by bipolar cautery. However, no hemostatic agents should be left internally post removal of spinal tumor. Fibrin glue could be used to improve quality for closing of dura matter.

Other category of hemostatic agents, fibrin sealants/glue provides effective hemostasis in diffuse bleeding during spinal surgeries. The surgeries, such as cervical disk surgery, spondylitis, tumor surgery, etc. Sekhar LN et al has published data on 20 patients showed that fibrin glue is effective in achieving hemostasis. Stoltze D and Harms J have distinctly elaborated the indications for use of fibrin sealants in spinal surgeries, such as for achieving hemostasis of perivascular vessels, intraspinal vessel systems (especially venous), for suture reinforcement in combination with autologous tissue or collagenous material for dura or dura reconstruction, or of blood vessels and for closure of remaining cavities or layers prone to complications, mostly in transoral spinal surgery (soft palate, back wall of the pharynx, etc.). Fibrin sealants provides all components necessary for fibrin clot formation and does not required any clotting component from the patients, achieving rapid hemostasis. Hence, it is useful as well in patients with coagulopathy, such as hemophilia. It is primarily used for large, oozing surface areas that can be quickly covered by applying the area with the mixture while providing the surgeon with a clear and clean view of the operative field.

In developed countries, fibrin sealant is also approved for suture line sealing in dura mater closure. It is also indicated as a tissue glue to promote adhesion/sealing, or as suture support in vascular surgery and in neurosurgery and surgical procedures where contact with cerebrospinal fluid or dura mater can occur. A clinical data, such as case reports and case series, are published to show the effectiveness of fibrin sealants in dural tear leading to CSF leakages in spine.

With the different types of bleeding scenarios usually observed in spinal surgery, the most commonly used topical hemostat appears to be gelatin, ORC and fibrin sealants. Literatures reviewed in this article supports not only there common use but also judicious use. Surgeons should always be careful to remove residual gelatin sponges to avoid their mass effect as there are several reports of severe neurological deficits due to the intraspinal application of absorbable gelatin sponges. Likewise, it is highly recommended to avoid over liberal use of ORC in all intraspinal and perispinal procedures to avoid incidence of paraplegia.

**SUMMARY**

Achieving hemostasis in spinal surgery is very critical to prevent further neurological damage. In addition to preoperative and postoperative measures, it is equally important to control perioperative bleeding by using topical absorbable hemostatic agents. Although the scarcity of evidences, hemostatic agents have proven the effectiveness in various spinal surgeries. The need is to generate more evidences in this most critical neurospine specialty, where few millimeter of blood loss can affect surgical outcome adversely.

**REFERENCES**