An overview of blood-sparing techniques used in spine surgery during the perioperative period

Abstract The problems linked to blood loss and blood-sparing techniques in spine surgery have been less studied than in other fields of orthopedics, such as joint-replacement procedures. Decreasing bleeding is not only important for keeping the patient’s hemodynamic equilibrium but also for allowing a better view of the surgical field. In spine surgery the latter aspect is especially important because of the vicinity of major and highly fragile neurologic structures. The techniques and agents used for hemostasis and blood sparing in spinal procedures are mostly similar to those used elsewhere in surgery. Their use is modulated by the specific aspects of spinal approach and its relation to the contents of the spinal canal. Blood-sparing techniques can be divided into two categories based on their goals: either they are aimed at decreasing the bleeding itself, or they are aimed at decreasing the need for homologous transfusion. Various hemodynamic techniques, as well as systemic and local drugs and agents, can be used separately or in combination, and their use in the field of spine surgery is reported. The level of evidence for the efficacy of many of those methods in surgery as a whole is limited, and there is a lack of evidence for most of them in spine surgery. However, several blood-saving procedures and drugs, as well as promising new agents, appear to be efficient, although their efficacy has yet to be assessed by proper randomized controlled trials.

Keywords Hemostasis · Spine surgery · Bleeding · Blood sparing · Prevention

Introduction

Blood loss in spine surgery is an important issue, even though it appears underestimated, or at least understudied, compared to hip and knee arthroplasty surgery. Blood loss, however, may be an acute problem not only in major deformity surgery but also in less extensive fusion procedures. Decreasing bleeding is important for maintaining a patient’s hemodynamic equilibrium and allowing a better view of the surgical field. In spine surgery, the latter aspect is especially important because of the vicinity of major and highly fragile neurologic structures. The surgeon’s comfort shortens surgery time, which further decreases bleeding.

In this article we will summarize the main techniques used to spare blood in spine surgery during the perioperative period: from the immediate pre-op to the post-op period. Most of those modalities will be described in greater detail elsewhere in this issue.

Blood-sparing techniques

Blood-sparing techniques can be divided into two groups based on their goals: they are aimed either at decreasing the bleeding itself, or at decreasing the need for homologous transfusion.
Methods aimed at decreasing bleeding

**Hemodynamic:**
- Controlled hypotension
- Local vasoconstrictors
- Epidural blockade

**Chemical/biological:**
- Systemic:
  - Desmopressin
  - Aprotinin
  - Tranexamic acid
  - Epsilon-aminocaproic acid
  - Oestrogens
  - Other
- Local:
  - Bone wax
  - Hemostatic “sponges” (gelatin, collagen, cellulose)
  - Fibrin sealants
  - Other

Methods aimed at decreasing homologous transfusion needs

**Hemodynamic:**
- Acute hemodilution
- Planned autologous transfusion
- Blood saving:
  - Perioperative: cell saving systems
  - Postoperative: drainage recovery systems or cell saving

**Chemical/biologic:**
- Erythropoietin (EPO)
- Substitutive oxygen carriers

Planned preoperative autologous donation and erythropoietin treatment will not be discussed here, as they take place many weeks prior to surgery and, therefore, are not truly perioperative. This paper will discuss all blood-sparing techniques reported in orthopedics, even if they have not (yet) been published in the context of spine surgery.

**Controlled hypotensive anesthesia**

Controlled hypotension has been used with success since the 1950s in orthopedic surgery [52]. It is widely applied to spine surgery, and good results have been published since the early 1970s [44, 66, 72, 84, 87, 91, 109].

However, Lennon et al. [77] report in a retrospective study that hypotensive anesthesia did not decrease transfusion requirements compared with normotensive narcosis in scoliosis surgery. The goal of hypotensive anesthe-

sia is to reach a systolic blood pressure of around 60–80 mm Hg. Many different drugs have been used over time, such as anesthetic gases [13], Ca channel blockers [75], beta-blockers [80], nitroglycerin, nitroprusside [59, 50], opiates [21] and anesthetic drugs.

The mechanism by which controlled hypotension decreases blood loss is still unclear and goes beyond the simple explanation that lower blood pressure induces lower blood extravasation. Some authors have hypothesized the existence of an ischemic wound during hypotensive anesthesia, but few studies have really tried to measure blood flow through scientific measures such as flowmetry. Lee et al. measured blood flow in the paraspinal muscles during spine surgery with two different hypotensive drugs, reaching a similar degree of hypotension. They found widely different values for local blood flow [73], although the blood losses were not very different. This indicates that the effect on local blood flow is not the only factor involved. The effect on blood flow in the epidural venous plexuses has also been hypothesized [74], and blood pressure by itself seems to be an important variable influencing blood loss [100].

In the context of spinal fusions, some authors report that, since bleeding is mainly linked to bone decortication and is, therefore, essentially venous, blood loss will not be influenced by a decrease in arterial pressure [15]. In their series of Jehovah’s Witnesses, Brodsky et al. [15] found that blood flow was correlated to surgery duration more than to blood pressure. Kakiushi [62] measured intrasosseous pressure in thoracic vertebral bodies during surgery and found that the intraoperative blood loss correlated with intrasosseous pressure but that the latter was not correlated to the arterial pressure.

Hypotensive anesthesia may lead to complications [81] and is contraindicated in some cases, mainly in patients with hypertension or ischemic disorders: coronary, cerebral or peripheric.

The possibility of neurological damage at the level of already compressed and compromised nerve roots, where hypotension could add to the suffering of the root, was raised by Krengel et al. [69]. The effect of hypotension on spinal cord function during scoliosis surgery has also been questioned [44]. However, although evoked potential monitoring may show temporary alterations, it does not appear that hypotensive anesthesia increases the risk of neurologic damage [45].

**Acute normovolemic hemodilution**

In this technique venous blood is collected at the beginning of the procedure, after the induction of anesthesia, in order to diminish hematocrit to a level around 30. In children even lower values can safely be attained (under 20) [33, 101]. The lost volume is compensated with synthetic colloids. Hemodilution can be combined with hypotensive anesthesia.