The use of intra-operative blood gas analysis in the investigation of suspected iatrogenic vascular injury

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Abstract

Background Iatrogenic injury to the vertebral artery during posterior cervical fusion is a rare and potentially disastrous complication. Differentiating arterial from brisk venous bleeding would be ideal to assist in the intra-operative management. Definitive angiography is typically not feasible during most routine spine surgery.

Case description We describe the case of a patient undergoing an occipitocervical fusion, where brisk bleeding was encountered during dissection of the CB lateral mass. While the dissection was thought to be superficial to critical structures, the nature of the hemorrhage could not be definitely determined by visual inspection by two senior surgeons. The hemorrhage did not readily cease with standard maneuvers such as, the application of various hemostatic agents. Simultaneous blood gas analysis was performed on samples obtained from the patient's radial

artery and from the hemorrhage in the operative bed. Comparative analysis concluded that the bleeding encountered in the surgical field was venous in nature.

Conclusion Blood gas analysis can be a useful adjunct in determining the nature of hemorrhage from vascular structures in spine surgery when visual inspection is indeterminate.

Keywords Blood gas analysis · Cerebrovascular trauma · Iatrogenic disease · Spine

Background

Iatrogenic injury to the vertebral artery during posterior cervical fusion is a rare and potentially catastrophic complication [1]. The vertebral artery courses through the cervical spine in the transverse foramen and can present with a variety of anomalies that must be taken into consideration during surgery [2]. Preoperative magnetic resonance imaging (MRI) is commonly obtained in many traumatic and degenerative conditions; however, dedicated vascular imaging is not. Even though the vertebral artery and its anomalies may be identified on preoperative MRI [2], iatrogenic injury is still possible. Injury can occur either at the time of dissection or during the placement of instrumentation. Hemorrhage from either a venous plexus or the vertebral artery can obscure the operative field and appear similar. Differentiating arterial from brisk venous bleeding is necessary, as intra-operative management strategies differ. We describe a technique of intra-operative blood gas analysis as a readily available means to identify the source of hemorrhage, whereas definitive angiography is typically not feasible during most routine spine surgery.

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Case presentation

A 74-year-old woman was undergoing an occipital-cervical fusion for the treatment of a C1 Jefferson fracture and type II odontoid fracture that failed to heal after rigid external bracing. She was placed in the prone position and a dissection was carried down in the midline to allow for placement of a rigid internal construct from an occipital plate to lateral mass screws at C3–5. While working on the lateral margin of the exposure at the right interlaminar space between CB–3, a significant amount of bleeding was encountered. The blood was dark in nature and non-pulsatile, suggesting a venous origin. However, repetitive hemostatic maneuvers such as the application of tamponade with thrombin soaked Gelfoam (Pfizer, New York, NY), oxidized cellulose, and SURGIFLO (Johnson & Johnson, Somerville, NJ) did not provide a durable effect.

To definitely determine that the hemorrhage was not arterial in origin, we allowed for the surgical field to get filled with blood over the course of two seconds and extracted a sample with a syringe, which was sent for a blood gas analysis. Simultaneously, we asked the anesthesiologist to send a blood sample from the radial artery catheter for arterial blood gas analysis (Table 1). Interpretation of these results concluded that the sample drawn from the operative field was venous in nature.

Reassured that this was venous bleeding, hemostasis was obtained with the application of crushed raw muscle specimen, harvested locally [3]. Subsequently, the occipital plate and lateral mass screws were placed in the standard fashion. Rods were attached creating a sturdy construct. Bone chip allograft was placed on the decorticated bone surface and the wound was closed in a routine, layered fashion. Blood loss was estimated at 350 cc. The patient recovered well from her operation without incurring any neurological deficit. Post-operative computed tomography (CT) angiography demonstrated proper placement of instrumentation and no evidence of vascular injury.

Discussion

Brisk bleeding during cervical spine cases can be encountered during dissection from the venous plexus,

from fractures in the bone, or from injury to the vertebral artery. While venous and bone bleeding can be quickly and easily solved, damage to the vertebral artery is a serious and potentially disastrous complication. During initial dissection, the vertebral artery is vulnerable to injury between the CB and 3 interlaminar space, particularly in the setting of anomalous and ectatic anatomy, or scar tissue. The vertebral artery is also prominently vulnerable at the C1–2 level, such as in the case of C1–2 trans-articular screw insertion [4]. Additionally, using the example of C1 lateral mass screws, the vertebral artery is vulnerable to injury as it leaves the transverse foramen of CB and lies in close proximity to the lateral mass of C1. Since there is considerable variability in the anatomy of the vertebral artery (it can course beneath the C1 posterior arch without passing through the transverse foramen), careful analysis of preoperative imaging and meticulous dissection must be always paramount. Despite these measures, vertebral artery injury can, and does occur.

Generally, bleeding can be dichotomized into either originating from a screw hole or an open space. When bleeding occurs during dissection, often during the lateral exposure of the C1–3 vertebra, it is imperative to determine whether it is arterial or venous in nature. Encountering the paravertebral venous plexus may cause significant hemorrhage and often heralds the proximity of the vertebral artery [5]. Tamponade is often used to control hemorrhage as an initial measure. Next, the source of hemorrhage should be identified as the ability to determine this has significant implications for both surgical management and post-operative care. For example, if vertebral artery injury is found in a patient with a contralateral hypoplastic artery, instrumentation may be abandoned to prevent further risk of devastating total posterior circulation compromise. Unilateral injury with robust contralateral circulation carries a low stroke risk (3.7%) [6]. Additionally, arterial hemorrhage which persists despite tamponade may require endovascular considerations, ligation, or direct repair. Postoperatively, arterial injury dictates further imaging and surveillance as delayed hemorrhage, arteriovenous fistula formation, and pseudoaneurysm formation have been reported following iatrogenic injury [7–10].

The technique of blood gas analysis from the operative field represents a novel use of a readily available test to the surgeon and anesthesiologist. While endovascular techniques require interventional neuro-radiologists, equipment, and preoperative planning, the ability to perform arterial blood gas is ubiquitous, requires little time to perform, and can provide valuable information. Knowledge of typical normal blood gas ranges is augmented by a simultaneous sample drawn from an indwelling arterial catheter, allowing for less ambiguity between samples with a given ventilator setting. Care must be taken to obtain the

Table 1 Blood gas analysis

Sample	1	2
FiO ₂	0.50	0.50
pH	7.27	7.23
pO ₂	241	64
pCO ₂	48	57

Sample 1 is drawn from the radial artery (FiO₂ = 40%). Sample 2 is drawn from the hemorrhage in the operative field. Units of partial pressure are mmHg

fresh 2–3 cc sample from the operative field directly and expel any remaining air bubbles from the filled syringe for accurate analysis. The specimens should also be analyzed immediately to allow for accurate results, as the partial pressure of oxygen in the blood in the operative field will quickly equilibrate with the atmospheric oxygen pressure given enough time.

Conclusions

Blood gas analysis can be a useful adjunct in determining the nature of hemorrhage from vascular structures in spine surgery when visual inspection is indeterminate.

Conflict of interest The authors declare that they have no competing interests.

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