Objective Measures For Estimating Intraoperative Blood Loss
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Abstract

Background: Current practice methods reveal no clear concise method of measuring intra-operative estimated blood loss. Many anesthesiologists and surgeons often estimate these totals on simple observation, which can offer wide-ranging values. This often leads to poor management with the transfusion of blood products in the perioperative patient. The purpose of this study is to provide objective endpoints for measuring intraoperative blood loss.

Methods: A clinical trial was conducted to provide a concise reproducible method of estimating blood loss. We used normal saline solution to measure the volume of fluid absorbed in commonly used surgical absorptive materials. Each material was trialed five times to produce a mean absorptive volume. This was determined for 25, 50, and 100% absorption coverage.

Results: Values obtained of the amount of volume absorbed at each of three different saturation percentages show that on average a 30x30 lap sponge holds the maximum volume at 61ml, while the surgical patties will absorb approximately 1ml, both at 100% saturation.

Conclusion: With the use of simple objective measures, such as the volumes absorbed by commonly used materials, the practice of estimating blood loss can be refined to offer valid endpoints for identifying the need for blood products.

Intro

Blood management in the operative patient is a complex issue. Current methods of estimation are poorly reproducible and are often grossly underestimated. Blood management should be common sense, while being both cost effective and simple to reproduce. In comparing methods from one institution to the next, there are gross differences in the estimation of blood loss (EBL). This in turn leads to varied predictors of the potential need for transfusion. There is currently no clear, concise method for predicting intraoperative blood loss. Therefore, the purpose of this study is to provide objective endpoints for estimating intraoperative blood loss.

Review of the literature

There are few prospective randomized controlled studies to address the most appropriate methods for predicting blood loss. A review of all meta-analysis studies on blood loss measurement, including the Cochrane Collaboration Library,
reveal the level of evidence is low in regards to most conclusions and statements in the literature. Mathematical models, such as those proposed by Brecher et al.\textsuperscript{1} have reported that calculations of blood loss were on average 2.1 times greater than the estimated blood loss provided by anesthesia.

Gravimetric methods have also been reported. Lee et al.\textsuperscript{2} compared gravimetric and laboratory methods of quantifying blood loss during animal surgery. Intraoperative blood loss was first quantified by measuring irrigation fluid and the weight of surgical sponges. Blood loss was determined as the weight difference between the sterile saline solution used and gauze sponges pre and post-operatively. A highly significant correlation was found between the laboratory method and the gravimetric method, supporting the use of weight measurement as an accurate option.

Furthermore, Sehat KR\textsuperscript{3} and colleagues report that with hip and knee procedures the surgeon should always account for what are labeled as “hidden” blood losses. These numbers have been attributed to intraoperative hemolysis and the extravasation of blood into the soft tissues. This can account for up to 1140ml in total knee arthroplasty and 840ml in total hip arthroplasty.\textsuperscript{4}

Based on the poor current level of evidence in these limited studies, and the hidden factors involved in these surgical cases, there is an undeniable need for additional clinical data models for estimating blood loss.

**Materials and Methods**

Given the paucity of data to support a universally accepted method, we constructed a simple model to provide a starting point for attempting objectivity at estimating blood loss. Absorptive materials used commonly in orthopedic procedures were used to measure the amount of saline
absorbed at varied levels of saturation (fig 1). These included a 30X30 cm lap sponge, 30X5 lap sponge, 4X4 Raytec, 2X2 surgical pattie, and the peanut sponge.

We first used methylene blue dye and normal saline solution to create a colored medium for measure. This solution was then placed into clearly marked graded cylinders. Each material to be tested was then placed into the fluid to an approximated percent saturation based on the visual coverage of the material. This was done for 25, 50, and 100% saturation (fig 2). We then measured the change in volume in the cylinder with each trial. The mean of 5 separate trials at each of the saturation intervals was calculated. This was determined to be the mean absorptive value.

**Results**

The mean absorptive value was greatest for the 30X30 lap sponge at all three intervals of saturation. With 61mls of volume absorbed at 100% saturation. The peanut offered the lowest absorptive value, with a max of 1ml at 100% saturation. Both 25, and 50% saturation data points could not be reliably be measured as the amount of visual coverage was indiscernible. Table 1 below displays these mean volumes at 25%, 50%, and 100% saturation.

<table>
<thead>
<tr>
<th>Material (cm)</th>
<th>25% saturation</th>
<th>50% saturation</th>
<th>100% saturation</th>
</tr>
</thead>
</table>
Table 1: Mean Saturated Volumes in commonly used absorptive materials (ml)

<table>
<thead>
<tr>
<th>Material</th>
<th>30X30 Lap Sponge</th>
<th>35X5 Lap Sponge</th>
<th>4X4 Raytec</th>
<th>2X2 Surgical Pattie</th>
<th>Peanut Sponge</th>
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</thead>
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<tr>
<td></td>
<td>12.5</td>
<td>7</td>
<td>6.1</td>
<td>0.3</td>
<td>*N/A</td>
</tr>
<tr>
<td></td>
<td>23.3</td>
<td>12.2</td>
<td>9.7</td>
<td>0.6</td>
<td>*N/A</td>
</tr>
<tr>
<td></td>
<td>61</td>
<td>18.9</td>
<td>13.5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* Partial saturations were unable to be accurately measured

Discussion

Beyond using absorption materials to gauge blood loss, there are a number of other considerations to take into account. Blood covered materials such as drapes, gowns, and instruments should all be accounted for in considering a final EBL. Suction canisters should be measured pre and post operatively and calculated minus the irrigation used in the case. It is also imperative that suction be used consistently throughout the case to offer a reservoir of measure at the end of the case, rather than simply a tool to keep the field dry. The amount of total irrigation used should also be closely measured by the scrub tech and charted.

The importance of communication with the anesthesia team is also essential. At our institution we communicate blood loss at 15-minute intervals with the anesthesia team. Their position behind the drapes often makes it difficult to visualize the operative field adequately in order to estimate the rate of blood loss at the surgical site. This also allows them to stay ahead with the potential need for intraoperative transfusion as well as appropriate blood pressure control.

The measurement of urine output (UOP) during the case is vital as it is the earliest indicator of hemorrhagic shock. Class I shock occurs with up to 15% of total blood volume loss (750ml)⁵, this in turn will lead to decreased UOP. UOP should
ideally be maintained at a rate 0.5ml/kg/hr or roughly 30ml/hr in the average adult. A decrease below this could indicate an early loss of blood volume, which could lead to decreased cardiac output and in turn lead to hypo-perfusion of the kidneys.

Furthermore, the measurement of preoperative hemoglobin and hematocrit will provide a baseline for measuring trends intra-operatively. Blood lost intra-operatively has, in theory, a hematocrit similar to the pre-operative value. Although one should keep in mind that this value may decrease as the patient receives large amounts of intravenous fluids in order to maintain normovolemia. For this reason many authors favor the use of mean post-operative hematocrit for the patient\(^6\). Howe and colleagues\(^7\) showed that the mean difference of preoperative hemoglobin vs. postoperative hemoglobin was 3.3 g/dL (SD 2.1). In their retrospective study, clinical estimation of blood loss, using a multiple linear regression model, was closely correlated with actual change in perioperative hemoglobin. While this offers some insight into the change in hemoglobin with surgery, it fails to clarify the accurate methods of estimating blood loss itself. This study does, however confirm the validity of EBL and its significance as it directly correlate as a predictor of change in hemoglobin.

It is important not only to measure the patient’s blood losses but also to be able address them with the appropriate means of correction. With the advancement of thrombogenic agents, a number of different materials are currently available to help minimize blood loss via direct thrombosis. Surgical hemostats, internal tissue sealants, and adhesion barriers provide the capability of direct thrombogenesis. Also, tools such as electro-cautery and harmonic scalpels have been shown to significantly reduced the amount of surgical wound hemorrhage\(^8\).

Basic surgical technique and care for soft tissues will avoid un-necessary trauma and injury to microvasculature. Simple considerations such as operative time management and operative approach, also contribute, as it well accepted that time of time a surgical wound is open is directly related to the increased need for
the transfusion of blood products. Moreover, allogeneic blood products, such as fresh frozen plasma, and platelets increase the patient’s coagulation potential in light of persistent hemodilution. Utilizing all of these tools in addition to the appropriate measurement of blood loss will provide the surgeon with a means of staying ahead.

**Summary**

The estimation of blood loss in the operative setting is inexact, and the amount is usually underestimated. Various attempts at using a number of different methods are poorly understood and difficult to replicate. This often leads to wide variability in measurements, which impacts the surgeon's management of resuscitation. Our report aims to offer a simple review of currently accepted techniques, and considerations to allow for a more judicious predictive model and path to informed decision making.

While the current literature is sparse with low levels of significance, there are certain mathematical models that can be incorporated as a tool. However, our review exposes the need for more randomized prospective clinical trials to further define clear objective measures. In addition, a simple focused observation of the saturation percentage of blood soaked materials can aid in a more precise estimation of blood loss intraoperatively.

Although blood screening has improved in safety considerably over the years, there are still known risks of transfusion, including potential reactions as well infectious risks, such as hepatitis, human immunodeficiency virus and bacterial sepsis. There is even emerging data suggesting that blood transfusion may be associated with risk of postoperative infection. The summation of all these considerations and simple techniques offer the surgeon a refined approach to managing the need for blood products and the awareness to avoid the potential deleterious effects of transfusion.
REFERENCES


