








## CLINICAL RESEARCH

# Intraoperative blood salvage in proximal femur epiphysiolysis surgical treatment with hip controlled dislocation technique: a case series study



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Received 5 May 2020; accepted 6 February 2021

Available online 11 June 2021

### KEYWORDS

Epiphysis, slipped;  
Blood transfusion,  
autologous;  
Operative blood  
salvage

### Abstract

**Objectives:** To report a case series of Intraoperative Blood Salvage (IOS) in surgeries during the treatment for Slipped Capital Femoral Epiphysis (SCFE) with controlled dislocation of the hip, identifying its efficacy, complications, and the profile of patients with SCFE.

**Methods:** Descriptive study reporting a case series, comprising patients seen between January 2016 and March 2018, diagnosed with SCFE, and treated with controlled surgical dislocation of the hip using IOS.

**Results:** Sample comprised of 15 patients, with a mean age of 13.1 years. The most affected side was the left with 8 cases. None of the patients required allogeneic blood in the postoperative period. Mean pre- and postoperative hemoglobin were 13.2 and 11.2 g.dL<sup>-1</sup>, respectively, and mean hemoglobin difference was 1.8 g.dL<sup>-1</sup>. Mean pre- and postoperative hematocrit were 39.13% and 33.20%, respectively, and mean hematocrit difference was 5.52%. No intraoperative complications were observed. One patient presented vomiting and another one, wound infection in the postoperative period.

**Conclusion:** IOS was an alternative blood salvage approach and prevented allogeneic blood transfusion, enabling reduction of potential complications.

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## Introduction

Slipped Capital Femoral Epiphysis (SCFE) is a condition that affects the hip of pre-adolescents and adolescents, characterized by an anterior slippage of the metaphysis of the femur neck on the subjacent proximal epiphysis due to a damaged physis. If untreated, the two major risks of the condition are: (1) progression to slipping and deformity, and (2) femoroacetabular impingement with consequent degeneration and progression to early hip arthrosis.<sup>1,2</sup>

Several techniques are used for adult patients to attempt to reduce blood loss and consequently reduce homologous blood transfusion requirements during major surgeries with anticipated large blood loss, such as: (1) acute normovolemic hemodilution, (2) hypervolemic hemodilution, (3) controlled hypotension, (4) antifibrinolytics, (5) autologous blood transfusion, and (6) intraoperative blood salvage (IOS).<sup>3</sup> These techniques tend to be neglected, however for pediatric patients.<sup>4</sup>

IOS is a technique that uses dedicated equipment that enables blood to be collected from the surgical wound and infused back to the circulatory system of the patient, intraoperatively.<sup>5</sup> The technique has proved to be an effective method to avoid allogenic blood transfusion,<sup>5,6</sup> and has been employed with satisfactory results in orthopedic surgeries both for adults<sup>6,7</sup> and pediatric patients.<sup>8-10</sup> Its use is substantiated in pediatrics when an appropriate strategy is required to avoid blood loss.<sup>11,12</sup> Therefore, it does not seem to bring about a negative impact on the clinical outcome of these patients.<sup>6</sup>

Despite the benefits of using IOS in orthopedic surgeries already described in the medical literature, there is lack of data as to its use in hip surgeries and, more specifically, in controlled hip surgical dislocation for SCFE, a major surgery with major blood loss. The present report aimed to describe and analyze the experience of a series of cases with IOS during surgeries to treat SCFE using controlled surgical dislocation of the hip, regarding clinical and economical aspects, and assessing its efficacy.

## Methods

The study is a case series based on the recommendations of the Case Report (CARE) guidelines.<sup>13</sup> It was carried out at a tertiary trauma hospital, with a sample comprised of patients seen in the period between January 2016 and March 2018, all diagnosed with SCFE and classified as both stable and unstable, and severe (slip angle > 50).<sup>14,15</sup> All were submitted to treatment by controlled dislocation of the hip using the Ganz technique and blood reinfusion by IOS during surgery.

Exclusion criteria considered were patients in whom IOS was not used, and those treated by other surgical techniques. The present work was submitted to and approved by the Institutional Ethics and Research Committee of Hospital Instituto Doutor José Frota.

The transfusion team responsible for using the IOS equipment took part in the surgical planning for each surgery. The equipment model used was the Autolog®. Intraoperative bleeding of each patient was collected, processed by the equipment, and afterwards reinfused to patients' circulatory system, by the anesthesia team, right after the end of the surgical stages with major risks of blood loss, that is, at the final moments of the surgical act. It is important to underscore that autologous blood, after processed, occasionally can be infused early in case of intraoperative hemodynamic instability, a scenario that did not occur during the surgeries of the patients of the present sample. It is also convenient to point out that all patients were operated on by the same surgeon.

The medical charts of patients who met inclusion criteria were analyzed, including clinical data and laboratory tests, such as preoperative and 6-h postoperative hemoglobin and hematocrit values.

Finally, data was collected at the blood center regarding costs related to IOS procedure and costs related to the transfusion of packed Red Blood Cell (RBC) bags, allowing for the comparison of intrinsic costs of both procedures.

**Table 1** Patients that comprised the sample.

Patients	Sex	Hb (g.dL <sup>-1</sup> )		Total volume suction from wound (mL)	Volume recovered (mL)	Age	Side
		Preoperative	Intraoperative				
1	Male	12.5	11.6	544	140	13	Right
2	Female	12.8	10.3	479	157	13	Left
3	Male	12.3	10.2	550	192	13	Left
4	Male	13.2	10	468	338	15	Right
5	Male	13	11.9	549	220	9	Left
6	Male	13.8	11.6	532	334	15	Left
7	Male	13.1	11.6	413	128	14	Right
8	Female	12	10.2	363	213	11	Right
9	Male	14	11.3	250	119	16	Right
10	Male	13.5	11.6	549	369	14	Left
11	Male	14.4	15.3	371	204	17	Left
12	Female	13.2	9.7	379	200	13	Right
13	Female	12.8	10	315	147	11	Left
14	Male	13.5	11.5	534	315	14	Left
15	Male	13.7	14	338	165	12	Right

**Table 2** Values and differences in Hemoglobin (Hb) and Hematocrit (Ht).

	Mean	Variation
Pre Hb (g.dL <sup>-1</sup> )	13.2	12 to 14.4
Post Hb (g.dL <sup>-1</sup> )	11.2	9.1 to 15.2
Difference in Hb (g.dL <sup>-1</sup> )	1.8	-0.9 to 4.3
Pre Ht (%)	39.13	34.3 to 44.4
Post Ht (%)	33.2	29 to 46.9
Difference in Ht (%)	5.52	-3.3 to 11.9

Data collected were analyzed using the Excel program after structuring tables.

## Results

During the period analyzed, 17 surgical procedures were performed on 16 patients to treat SCFE using IOS in the trans-operative period. We excluded one patient who was not submitted to blood salvage due to low-rate intraoperative bleeding, and the blood collected was not sufficient to fill one bowl – part of the equipment that works as a recipient, directing what is collected to the centrifuge. Thus, there was a total of 15 procedures on 15 patients (Table 1).

The mean patient age observed was 13.1 years (9–17 years), with a predominance of men, 11 cases (78%), and the left hip was more frequently affected in 8 cases (53%).

Of the 15 procedures in which blood was salvaged, the mean re-infused volume was 216.06 mL (119 to 369 mL) from a mean volume suctioned from the surgical wound of 442.2 mL (250 to 550). Mean preoperative and postoperative hemoglobin were 13.2 g.dL<sup>-1</sup> (12 to 14.4) and 11.2 g.dL<sup>-1</sup> (9.1 to 15.3), respectively. The mean difference in hemoglobin variation was 1.80 g.dL<sup>-1</sup> (-0.9 to 3.2) for patients for which there was intraoperative blood salvage. Mean preoperative and postoperative hematocrit were 39.13% (34.4 to 44.4), and 33.20% (29 to 46.9), respectively. The mean difference in hematocrit variation for patients with blood salvage was 5.52% (-3.3 to 9.8). The results of means and differences in hemoglobin and hematocrit are presented in Table 2.

It is worth underlining that a higher level of postoperative hematocrit and hemoglobin were observed in comparison to preoperative measurements for 2 patients of the study who received IOS.

No intraoperative events were found, albeit, 1 (7.1%) patient presented vomiting on the first postoperative day, and 1 (7.1%) patient presented surgical wound infection after 3 days. It is worth to point out that none of the patients in the study required allogenic blood transfusion during the postoperative period, and none of the limbs required reoperation.

Total costs of the IOS procedure were R\$751.62 (approximately US\$141 according to quote of September 14, 2020) per procedure, including prices of material used and professional fees.

## Discussion

The treatment of SCFE is surgical, mainly aimed at avoiding progression of deformity.<sup>16</sup> The controlled surgical dislo-

cation of the hip is a procedure to rebuild and stabilize slipping of the proximal femoral epiphysis in order to restore full functionality. The surgical technique has a long learning curve, and is considered a major surgical procedure, anticipating major trans-operative bleeding. Thus, it is indispensable to use blood salvage strategies.

In a Cochrane review that analyzed 75 randomized studies between 1979 and 2008, orthopedic surgeries that used IOS presented a 54% reduction in allogenic transfusion requirements.<sup>17</sup> Less allogenic transfusions proved beneficial to prevent using low quality red blood cells with less flexible membranes, lower levels of enzymes responsible for oxygen delivery and more likely to undergo hemolysis, when compared to RBC collected during IOS.<sup>18–20</sup>

Decrease in allogenic blood use also has advantages by decreasing patient exposure to post blood transfusion complications. Among them, we point out infections such as HIV or hepatitis B and C; and non-infectious complications, associated with a higher mortality risk,<sup>22</sup> such as anaphylactic reaction, acute pulmonary injury, immunosuppression, and acute or late transfusion hemolytic reaction.<sup>21</sup> Children are more susceptible to adverse effects, given individuals under 18 years present an incidence of 18 per 100 thousand transfusions, and the reported incidence in children under 1 year, is 37 per 100 thousand transfusions.<sup>23</sup>

Although IOS is a procedure with visible benefits, it is not exempt of risks and rare complications. Potential incidents have been described, such as hydro electrolytic disorders, gas or fat embolism and coagulation disorders, given platelets and coagulation factors are not recovered.<sup>24</sup> Notwithstanding, in the abovementioned Cochrane review, adverse effects and complications were not statistically relevant to establish an association with IOS, or the need for new surgeries, thromboses, or extended length of hospital stay.<sup>17</sup> None of the patients of the present study presented any of the complications mentioned.

In our study, one of the patients presented vomiting in the postoperative period, that was controlled with antiemetic medication. Another patient presented seropurulent exudate in the surgical wound, that improved clinically with intravenous antibiotics. It is important to point out that there were no hematological complications, such as hemolysis.

Indication of IOS is considered for patients with risks of bleeding above 10% of the blood volume, that is, generally, about 500 mL.<sup>25,26</sup> In pediatrics, in turn, indication is for patients with an estimated loss above 8 mL.kg<sup>-1</sup> for children over 10 years of age.<sup>25</sup> Moreover, another indication would be patients who cannot undergo allogenic transfusion for religious imposition, and IOS is an alternative.<sup>26</sup> There are no absolute contraindications for performing IOS.<sup>26</sup>

In a controlled study of 2019 with IOS in hip surgeries, the authors observed a higher mean in the levels of blood hemoglobin (11.2 g.dL<sup>-1</sup>) in the group in which IOS was used, than in the control group that did not use it (8.2 g.dL<sup>-1</sup>). Mean hematocrit levels in the group with IOS was 33%, while for the control group, mean hematocrit value was 25%.<sup>27</sup> However, several surgical techniques and age groups were assessed, making the comparison limited for the study. Literature data on the treatment of scoliosis also have shown that IOS is capable of providing higher postoperative hemoglobin levels than in the control group.<sup>28</sup>

Due to ethical limitations, the present study could not use a control group for comparison, given there is no standard procedure in the literature besides the technique used. Despite the limitation, the authors reported the excluded patient in the analysis, given the patient did not receive intraoperative IOS reinfusion and presented the highest variation in the level of pre and postoperative hemoglobin and hematocrit, with a 4.3 g.dL<sup>-1</sup> and 11.9% decrease, respectively.

From what has been shown from the costs standpoint, IOS seems to have an economic advantage for the health system, reducing costs in pediatric surgeries and in spine surgeries in adolescents.<sup>11,12</sup> Fixed intrinsic costs of the IOS procedure are equivalent to the costs of producing packed RBC when the amount of blood salvaged is approximately 2.35 units of RBC (each unit has an average 280 mL).<sup>12</sup> IOS was observed to be more economical when bleeding was approximately 500 to 600 mL in another study in spine surgeries.<sup>29</sup>

Similar results were found in the present study. Total costs of IOS were calculated as approximately R\$751,00 (roughly US\$141, on September 14, 2020) per procedure. Therefore, this figure is equivalent to the costs of 2.38 units packed RBC, given the cost of one unit of packed RBC is R\$315.18 (approximately US\$59 on the same date above). Therefore, in major surgeries, such as in controlled surgical dislocation of the hip, when more than one bag of RBC is required for hemodynamic stabilization of the patient, IOS can be a beneficial strategy.

However, in addition to comparison of financial costs between IOS and transfusion of allogenic RBC, there are also factors for which pricing is challenging. The difficulty is inherent to collecting RBC, because it depends on donors, which makes it a low availability resource in the health system, mainly for less prevalent blood types and for patients with blood incompatibility factors.

## Conclusion

This case series suggests IOS as an efficient alternative to decrease allogenic blood transfusion during surgical repair of slipped capital femoral epiphysis. The study showed that IOS is a safe technique with minimum complications and can be an alternative to reduce costs when re-infusion of higher volumes of blood are required. Furthermore, we suggest the need for further studies to better characterize IOS as an efficient, safe and cost-beneficial technique for several surgical procedures.

## Conflicts of interest

The authors declare no conflicts of interest.

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