

**Factors Associated with Allogenic Blood Transfusion After Reconstructive Hip Surgery  
in Patients with Cerebral Palsy**

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**ABSTRACT:**

**Background:** The hip joint tends to be highly affected in patients with Cerebral Palsy (CP). Subluxation, problems with ambulation, posture, perineal hygiene, and pain can result. Severe cases often require corrective surgery of the affected dysplastic hip(s). This often is accomplished with varus derotational osteotomy (VDRO), femoral osteotomy, pelvic osteotomy, tendon releases/lengthening, or a combination of any of these procedures. These reconstructive hip surgeries can result in marked blood loss. Due to the highly vascularized nature of bone, surgery can result in marked blood loss. This increases the transfusion burden on the patient and increases exposure to blood products and the associated risks therein. By identifying the risk factors that contribute to intraoperative and postoperative blood loss, targeted strategies may be developed to reduce this risk to the patient.

**Aims:** The purpose of this study is to provide descriptive analysis of the pediatric CP population undergoing corrective hip surgery. We will attempt to identify various risk factors that may predispose patients to significant blood loss during reconstructive hip surgery. This study will be the largest study analyzing blood management therapy with the VDRO procedure.

**Methods:** This is a retrospective chart review of consecutive CP patients who have undergone reconstructive hip surgery at a single institution from 2000 to 2012. Demographic data to be analyzed includes patient age, gender, race/ethnicity, height, weight, BMI, and medical comorbidities. Also, type of procedure performed, bilateral vs unilateral reconstruction, specific diagnosis, preoperative hemoglobin and hematocrit (H and H), pre-transfusion H and H, estimated blood loss (EBL), total operative time, cell saver volume, units transfused, complications, quantity of postoperative transfusion, and post-transfusion H and H was recorded. Data was compared using the Chi-squared method, or non-parametric analog, to assess the likelihood of the need for postop transfusions as an initial univariate analyses.

**Results:** 87 patients were included in the study. There was no significant relationship between the use of autologous blood and age, gender, weight, height, or BMI. Patients who received autologous blood also had a higher EBL ( $p=0.029$ ) and were more likely to need allogenic transfusion ( $p=0.023$ ). Concomitant DEGA procedure carried a 2.25 times relative risk of needing blood transfusion ( $p<0.001$ , 95% CI 1.402-3.611). Bilateral VDRO was 1.64 times more

likely to need a transfusion, however this was not quite statistically significant ( $p=0.052$ , 95% CI 0.972-2.756)

Conclusion: Varus derotational osteotomy for the correction of neuromuscular hip dysplasia can be associated with excessive blood loss, especially in the CP patient population. The use of autologous vs allogenic blood products carries various risks and benefits. This paper has identified that the need of concomitant DEGA osteotomy is correlated with increased blood loss. Also, the use of autologous blood product is correlated with increased blood loss.

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## **Introduction/Significance:**

Cerebral palsy (CP) is the most common cause of motor disability in childhood.<sup>1</sup> Behind trauma, CP is the most common diagnosis in the pediatric orthopedic setting.<sup>2</sup> It is estimated that in the United States, approximately 3.3 per 1000 live births will be affected by CP, with a significantly higher prevalence in boys than in girls (male/female ratio 1.4:1).<sup>1</sup> CP is a static encephalopathy that encompasses a group of motor impairment syndromes.<sup>18</sup> Of the various gross motor impairments, increased muscular spasticity, most commonly in the hip adductor compartment (adductor longus, brevis, and magnus muscles), often leads to hip dysplasia and dislocation, especially in patients with severe CP and those without gait function.<sup>2-8</sup> If untreated, problems with ambulation, posture, perineal hygiene, and pain can result.<sup>6,9</sup>

Although not a measure of spasticity, the Gross Motor Function Classification System (GMFCS) is commonly used to assess motor function in patients with CP and to predict an individual's prognosis.<sup>26</sup> Due to these impairments, severe cases often require corrective surgery of the affected dysplastic hip(s). This often is accomplished via varus derotational osteotomy (VDRO), femoral osteotomy, pelvic osteotomy, tendon releases/lengthening, or a combination of any of these procedures for the best long-term outcomes.<sup>7,8,10-14</sup> VDRO will be the primary mode of hip reconstruction analyzed in this study with emphasis on blood loss during these procedures.

Due to the highly vascularized nature of bone, reconstructive hip surgery can result in marked blood loss. In 2008, Puliado et al. found that the vast majority of patients undergoing periacetabular osteotomy required some form of blood transfusion, with 20% of patients requiring the use of allograft blood. However, excessive blood loss during the intraoperative and postoperative period increases the transfusion burden on the patient. This leads to increased exposure to blood products and the associated risks therein, including increased rate of infections, hemodynamic instability, decreased cardiac, pulmonary, and renal function secondary to fluid shifts, and even death.<sup>15</sup> In an analysis of the 1996 to 2005 Serious Hazards of Transfusion (SHOT) data, Stainsby et al.<sup>19</sup> estimated that the incidence of adverse reactions to be 18:100,000 in children less than 18 years old, and 37:100,000 in infants. These inherent

risks with transfusion of blood products have stimulated much research into alternative blood replacement strategies.

Alternative strategies to allogeneic blood replacement therapy include acute normovolemic hemodilution (ANH), hypervolemic hemodilution, deliberate hypotension, antifibrinolytics, intraoperative blood salvage (IABS), and preoperative autologous donations.<sup>20-23</sup> Prophylactic strategies such as predonation with erythropoietin, tranexamic acid, and aprotinin also exist and have shown that the rate of allogeneic blood transfusion may be decreased under certain circumstances.<sup>15</sup> The focus of our study is the IABS method. In a comprehensive review of transfusion risks and alternative blood replacement strategies by Lavoie<sup>23</sup>, IABS was identified as a commonly used strategy, but acknowledged that most of the pediatric data for this method existed in the field of scoliosis surgery. In a retrospective case–control study of patients undergoing posterior spinal fusion, Bowen et al.<sup>24</sup> found that the use of IABS was associated with lower rates of allogeneic blood transfusions, especially in surgeries of more than 6 hours in duration and estimated blood loss greater than 30% of estimated blood volume. In surgeries lasting over 6 hours, the relative risk of receiving an allogeneic blood transfusion was 5.87 in the group without IABS versus 2.04 in the group using IABS. Mirza et al.<sup>25</sup> concluded that IABS was effective in reducing allogeneic blood transfusion and postoperative anemia in patients undergoing anterior spinal instrumentation. By identifying the risk factors that contribute to intraoperative and postoperative blood loss, targeted strategies may be developed to reduce these risks to the patient. Although patient and surgical factors are known to influence operative blood loss during reconstructive hip surgery<sup>16,17</sup> they have not been well identified or studied using a large enough patient population as it pertains to reconstructive hip surgery. This study aims to identify the risk factors leading to increased intra-operative and post-operative blood loss in CP patients undergoing reconstructive hip surgery. Furthermore, based on these risk factors, we will attempt to determine if blood loss can be reliably predicted. This information could enable targeted use of available blood salvage techniques and be useful for counseling patients and their families before surgery as well as decrease overall healthcare costs.

**Methods:**

A retrospective chart review of consecutive CP patients who have undergone reconstructive hip surgery at Phoenix Children's Hospital (PCH) in Phoenix, Arizona from 2000 to 2012 was completed. The subjects were identified by electronic search of the hospital ICD9 and discharge diagnoses. This was a chart review only, and patients were not contacted. This study was reviewed and approved by the PCH and Institutional Review Board.

The inclusion criteria for this study are all patients with CP under 18 years old who underwent hip reconstruction orthopedic surgery at PCH from 2000 to 2012. The exclusion criteria are patients older than 18 years old and patients without CP undergoing hip reconstruction (those children with other hip disorders).

Demographic data to be analyzed includes patient age, gender, race/ethnicity, height, weight, BMI, and medical comorbidities. Other data to be analyzed includes the type of procedure performed, bilateral versus unilateral reconstruction, specific diagnosis Preoperative hemoglobin and hematocrit (H and H), pre-transfusion H and H, estimated blood loss (EBL), total operative time, cell saver volume, units transfused, complications, quantity of postoperative transfusion, and post-transfusion H and H.

Simple, univariate analysis was utilized via SPSS Statistics. As this is a descriptive, retrospective chart review analyzing patient outcomes and risk factors, data was analyzed between groups using the Chi-squared method, or non-parametric analog, to assess the likelihood of the need for postop allogenic blood transfusions as an initial univariate analyses. Statistical significance will be defined as an alpha of 0.05, with two-sided alternative hypotheses.

**Results:**

The descriptive statistics for the patient population are seen in Tables 1 and 2 below. The average patient age was 9 years and average hospital length of stay (LOS) was 3.75 days. The mean surgery time was 151.6 minutes and the mean estimated blood loss was 239.71mL. 52.9% of patients were female, 47.1% were male. 54% of patients underwent bilateral VDRO. 43.7% required some form of transfusion, either autologous blood product or allograft product. 32.2% required autologous blood product. 44.8% of patients had a concomitant pelvic/DEGA osteotomy in addition to the VDRO.

**Table 1 – Demographic data.** Descriptive statistics. 87 patients were included in the study. The basic, descriptive data for these patients is listed here. The average patient was 9 years old, stayed in the hospital for 3.75 days, and lost an average of 239.71mL of blood during their procedure. LOS = length of stay, EBL = Estimated blood loss, BMI = Body mass index.

	Average	Std. Deviation
Age (years)	9.06	3.37
LOS (days)	3.75	2.5
Weight (kg)	26.18	13.48
Height (cm)	123.69	19.53
BMI	16.73	3.89
Surgical Time (mins)	151.6	47.02
Units Blood Transfused	0.49	0.64
Autologous Blood Given (mL)	87.14	196.39
EBL (mL)	239.71	202.44
ICU Days	0.79	1.79

**Table 2 – Demographic data.** More patient demographics including gender distribution, bilateral versus unilateral procedures performed, and the transfusion totals are all displayed in this table. Gender distribution and the percentage of bilateral and unilateral procedures were near equal. 44.8% of patients had a concurrent pelvic osteotomy, 43.7% of patients needed a blood transfusion after their procedure, and 32.2% were given autologous blood.

	Total	Percent
Male	41	47.1
Female	46	52.9
Bilateral Hip Surgery	47	54
Unilateral Hip Surgery	40	46
Concurrent Pelvic Surgery	39	44.8
Patients Transfused	38	43.7
Pts. receiving Autologous Blood Products	28	32.2

There were no statistically significant correlations between the use of autologous blood products and the demographic data including age, LOS, height, weight, BMI, surgery time. However, patients who received autologous blood product were significantly more likely to also need a blood transfusion ( $p=0.029$ ) (Table 3). Although a bilateral VDRO was not quite significant with respect to increased blood loss compared to the unilateral ( $p=0.052$ ), those patients needed bilateral VDRO were 1.64times more likely to need transfusion (95% CI 0.972-2.756).

**Table 3 – Demographic data versus the use of autologous blood product.** Correlation with autologous blood product. This table is a comparison of the patient demographic data versus those that received the administration of their own, autologous blood. This was a t-test for equality of means. Note that the only statistically significant finding was that patients who received autologous blood product were more likely to also need a blood transfusion ( $p=0.029$ ). Significance was defined as  $p<0.05$ . LOS = length of stay, BMI = Body mass index.

	2-tailed Sig.
Age (years)	0.767
LOS (days)	0.528
Weight (kg)	0.882
Height (cm)	0.334
BMI	0.226
Surgical Time (mins)	0.326
Units Blood Transfused	0.066
EBL (mL)	0.29
ICU Days	0.239

When there was concomitant DEGA osteotomy in addition to the VDRO there was significantly more blood loss ( $p=0.022$ ). Surgery was also significantly longer ( $p=0.018$ ) with the concomitant DEGA procedure as well. Patients who had concomitant DEGA were more likely to need transfusion ( $p<0.001$ ) and required more blood products ( $p=0.000$ ) and were significantly at higher risk of requiring ICU admission ( $p=0.037$ ). The concomitant DEGA resulted in a 2.25 times increased risk of needing blood product transfusion ( $p=0.027$ , 95% CI 1.402-3.611).

## Discussion:

Neuromuscular hip dysplasia (NMHD) in patients with cerebral palsy (CP) can be a significant negative impact on the patient's and their family's quality of life. Progressive hip dysplasia can lead to difficulty with ambulation, posture, perineal hygiene, and pain.<sup>6,9</sup> In addition, dislocation or impending dislocation is the primary impetus for corrective surgery like the varus derotational osteotomy (VDRO) and pelvic osteotomy (DEGA) procedures.<sup>27</sup> Several studies have demonstrated long-term benefits of these corrective procedures.<sup>28,29,30</sup> This study did not identify any demographic data that could be used for prognostic information, however the presence of bilateral VDRO and also the concurrence of a pelvic osteotomy were found to increase a patient's risk for increased blood loss.

Despite the functional benefits that come with such corrective surgeries, the highly vascularized nature of the proximal femur and the pelvis predispose these patients to large volume blood loss, often requiring the use of blood product transfusion. Although less data exists for blood loss in the setting of hip osteotomy, there does exist data in the field of scoliosis surgery. Jain et al.<sup>31</sup> demonstrated that patients with CP have significantly more blood loss than patients with idiopathic or other syndromic causes of scoliosis. Furthermore, the use of antifibrinolytics have been investigated and have demonstrated positive outcomes when used in spine surgery<sup>32,33</sup>, however, the use of autologous blood transfusion in either setting (scoliosis surgery and hip surgery) has not been well-studied in the pediatric CP population. Based on the results of this study, the most robust risk factors identified to predict the need for blood transfusion in the setting of VDRO were concomitant DEGA (2.25x risk,  $p < 0.001$ , 95%CI 1.402-3.611), length of surgery, and the use of cell saver (although this was close, it did not reach statistical significance ( $p = 0.052$ , 95% CI 0.972-2.756)). Patients who had autologous blood transfusion did have a significantly higher average EBL ( $p = 0.029$ ). The magnitude of surgery likely explains this relationship well. In those larger surgeries, with higher EBL, there was more likely to be enough autologous blood collected for re-transfusion. Likewise, the larger surgeries likely needed both autologous blood product and allogenic product. Regardless, the use of autologous blood product did not reduce the need for transfusion, which was one of the

primary aims of the study. Factors such as gender, weight, height, BMI, and age did not present significant risk factors that could be identified for prognostic purposes.

**Future Direction:**

Further research is needed to help determine the overall utility of autologous blood product in this patient population. Although this is the largest study of its sort to date, one potential limitation of the study was the high degree of concomitant procedures in this study. In addition to the DEGA osteotomy, procedures such as tendon lengthening were commonly performed also. Without a larger patient population, it would be extremely difficult to identify how these other concomitant procedures contribute to overall blood loss. Furthermore, this is a retrospective review done at a single institution, which inherently carries multiple risks for certain biases. For example, the fact that those patients who had autologous blood product were at higher risk for needing blood transfusion. This possibly points to a selection bias. A larger, multicenter study would help address these limitations. Another potential future study could look at the cost-benefit analysis of the use of autologous blood collection systems versus allogenic transfusion.

**Conclusion:**

This study demonstrates that the use of autologous blood product in the setting of VDRO does not reduce the risk of needing allogenic blood product. Furthermore, important risk factors, such as time of surgery and the presence of concomitant procedures like the DEGA pelvic osteotomy, were identified and can be used in the future to identify those patients that may be predisposed to higher blood loss.

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