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Workgroup 5:

Blood Conservation

Liaison: Mohammad R. Rasouli, MD

Leaders: Luiz Sérgio Marcelino Gomes, MD, PhD (International), Brian Parsley, MD (US)

Delegates: Wael Barsoum, MD, Hari Bezwada, MD, James Cashman, MD, Julio Garcia, MD, William Hamilton, MD, Eric Hume, MD, Tae Kyun Kim, MD, Rajesh Malhotra, MD, Stavros G. Memtsoudis, MD, PhD, Alvin Ong, MD, Fabio Orozco, MD, Douglas E. Padgett, MD, Ricardo J. Reina, MD, Marco Teloken, MD, Emmanuel Thienpont, MD, Jonathan H. Waters, MD

QUESTION 1: Is blood transfusion associated with an increased risk of surgical site infection (SSI)/periprosthetic joint infection (PJI)?

Consensus: Yes. Allogeneic blood transfusions are associated with an increased risk of SSI/PJI. The role of autologous transfusion in the risk of SSI/PJI remains inconclusive.

Delegate Vote: Agree: 91%, Disagree: 5%, Abstain: 4% (Strong Consensus)

Justification:

Based on the Centers for Disease Control and Prevention (CDC) guideline, perioperative allogeneic blood transfusion in arthroplasty increases the risk of SSI/PJI. The association between autologous blood transfusion and the risk of SSI/PJI is less clear.

According to high-quality evidence from two randomized controlled trials (RCTs) and 4 observational studies, there is an increased risk of SSI with any blood transfusion (allogeneic, autologous, and autologous plus allogeneic blood transfusion data combined) as compared to no transfusion. This is further supported by both a meta-analysis of 6 studies (n = 8,493) [odds ratio (OR): 1.56; 95% confidence interval (CI): 1.18–2.06; $P = 0.002$] and a meta-analysis (n = 7,484) of 4 observational studies (OR 1.59; 95% CI: 1.15–2.18; $P = 0.004$) [1].

Data from a meta-analysis (n = 970) of 2 RCTs in hip arthroplasty suggest that autologous blood transfusion is not associated with an increased risk of SSI when compared to no blood transfusion (OR: 1.15, 95% CI: 0.43–3.13; $P = 0.78$) [1].

Low-quality evidence from a meta-analysis (n = 5,737) of 4 observational studies indicates that allogeneic blood transfusion is associated with an increased risk of SSI (non-adjusted OR: 1.46, 95% CI: 1.09-1.95, $P = 0.01$) [1].

Evidence from a meta-analysis (n = 2,592) of three observational studies shows that transfusion with allogeneic blood increases the risk of SSI as compared to transfusion with autologous blood (OR: 4.57, 95% CI: 2.39–8.73, $P < 0.0001$) [1]. The study by Innerhofer et al [2] demonstrated a clear increased risk for allogeneic blood over autogenous blood (high overall infection risk in this study). White cell depletion does not appear to affect the infection rate with autologous blood in hip surgery [3].

Evidence from one RCT and two observational studies indicates no increased risk of SSI in patients who receive both autologous and allogeneic blood transfusions) [1].

QUESTION 2: What are the predictors of the need for allogeneic blood transfusion in patients undergoing surgery for TJA?

Consensus: A lower preoperative hemoglobin level is the strongest predictor for the potential need for allogeneic transfusion after TJA. The use of general anesthesia, higher Charlson comorbidity index, female gender, and longer duration of surgery are predictors of the potential need for allogeneic blood transfusion in patients undergoing total joint arthroplasty (TJA).

Delegate Vote: Agree: 90%, Disagree: 4%, Abstain: 6% (Strong Consensus)

Justification:

The above-mentioned factors have been described as predictors of allogeneic blood transfusion in patients undergoing primary TJA. However, in these studies various "transfusion triggers" have been utilized, with a lower transfusion rate seen when a lower predefined Hgb level is used (currently 7–8 g/dL). Currently the most "optimal" hemoglobin threshold for transfusion remains unknown. The only prospective randomized controlled trial in orthopaedics is the FOCUS trial [4], which found no outcome differences with transfusing above or below 8 g/dL. The results of this trial were similar to those found in the TRICC trial [5]. There are also many studies emphasizing the effect of operative time on perioperative blood loss and transfusion rate [6–17].

In a single-institute study of 11,373 TJAs, including 4,769 total knee arthroplasties (TKAs) and 6,604 total hip arthroplasties (THAs), multivariate analysis indicated that male gender (263.59 mL and 233.60 mL in hips and knees), Charlson comorbidity index of >3 (293.99 mL and 167.96 mL in hips and knees respectively), and preoperative autologous blood donation (593.51 mL in hips and 592.30 in knees) increase the amount of blood loss [18]. Regional anesthesia compared to general anesthesia reduced the amount of blood loss. Amount of blood loss in both THA (OR: 1.43, 95% CI: 1.40–1.46) and TKA (OR: 1.47, 95% CI: 1.42–1.51) and Charlson comorbidity index-only in TKA patients (OR: 3.2, 95% CI: 1.99–5.15) increased risk of allogeneic blood transfusion. Preoperative autologous blood donation (OR: 0.01, 95% CI: 0.01–0.02 in hips and 0.02, 95% CI: 0.01–0.03 in knees) decreased the risk of allogeneic blood transfusion.

In a study by Faris et al [19], the predictive power of 7 preoperative variables (hemoglobin concentration, age, erythropoietin level, ferritin concentration, serum iron, total iron-binding capacity, and predicted blood volume) on the risk of transfusion in orthopaedic patients was tested in 276 surgical cases. The authors found that baseline hemoglobin concentration and predicted blood volume were significant predicators of transfusion risk. They also found an inverse correlation between hemoglobin concentration and transfusion risk. Placebo-treated patients with hemoglobin >10 to ≤13 g/dL had an approximately two times greater risk of transfusion than patients with hemoglobin >13 g/dL.

The study by Perazzo et al [20] also confirmed that the preoperative hemoglobin level was a strong predictor of need for blood transfusion

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following TJA. They assessed the association between preoperative autologous blood donation and risk of transfusion in 600 TJA patients including 312 THAs and 288 TKAs. The authors suggested that a preoperative autologous donation may not be necessary. Their data also suggested that the use of a cell salvage system may be effective in reducing the blood transfusion rate.

The study by Hamaji et al indicated that preoperative fluid loading can reduce the transfusion requirement and possibly infection rate; however, it was a small study with a high infection rate [21]. Colloid may be preferable over crystalloid [22] and neither method has a significant effect on clotting *in vitro* [23].

QUESTION 3A: What is the role of the type of anesthesia in minimizing blood loss and allogeneic blood transfusion during arthroplasty surgery for PJI?

Consensus: Compared to general anesthesia, neuraxial anesthesia reduces the amount of blood loss during TKA or THA.

Delegate Vote: Agree: 77%, Disagree: 11%, Abstain: 12% (Strong Consensus)

QUESTION 3B: Is there evidence against neuraxial blockade in PJI cases (due to probable risk of spreading infection)?

Consensus: No. The decision to use neuraxial versus general anesthesia in patients with PJI lies with the anesthesia team and needs to take into account the numerous benefits of neuraxial anesthesia versus the potential for development of infectious central nervous system complications (arachnoiditis, meningitis, and abscess) with the use of anesthesia.

Delegate Vote: Agree: 83%, Disagree: 6%, Abstain: 11% (Strong Consensus)

Justification:

Several systematic reviews and meta-analyses [24–28] compared neuraxial with general anesthesia regarding the amount of blood loss and blood transfusion during TJA. All these reviews support the role of neuraxial anesthesia in reducing amount of blood loss and transfusion requirements.

A meta-analysis by Hu et al [25] of 21 randomized controlled trials (RCTs) published from 1966 to April 2008 was performed to study the relationship between type of anesthesia and transfusion requirement. Pooled results from these trials showed that neuraxial anesthesia reduces the operating time (OR: −0.19; 95% CI: −0.33 to −0.05) and transfusion requirement (OR 0.45; 95% CI: 0.22–0.94) compared with general anesthesia. Furthermore, a systematic review of 18 studies published from January 1990 to October 2008 involving 1,239 THA patients showed that blood loss may be reduced in patients receiving neuraxial anesthesia compared to general anesthesia [26]. Another systematic review of articles published up until 2004 showed that neuraxial anesthesia reduced the number of transfused THA patients ($P = 0.0009$) [24]. The authors concluded that neuraxial blocks have a clear and definite effect on surgical blood loss and result in a reduction in the number of transfused patients. Also, a meta-analysis of 10 clinical trials whose results were published up until August 2005, including 330 THA patients under general anesthesia and 348 patients under neuraxial block, indicated that neuraxial block decreases total operative time by 7.1 min/case (95% CI: 2.3–11.9 min) and intraoperative blood loss by 275 mL/case (95% CI: 180–371 mL) [28]. Another study by Stundner et al [29] demonstrated that neuraxial anesthesia versus general anesthesia significantly reduced overall complications, including the transfusion requirement. Lastly, using a large database, Memtsoudis et al [30] demonstrated that the need for blood transfusion was reduced with neuraxial versus general anesthesia.

On the contrary, a systematic review of 28 studies published from January 1990 to October 2008 involving 1,538 TKA patients failed to find any evidence supporting a lower amount of blood loss or blood transfusion for patients receiving regional compared to general anesthesia [27].

A meta-analysis of 17 RCTs about various orthopaedic surgeries including TJA indicated that induced hypotension can reduce blood loss by approximately 287 mL of [95% CI: −447, −127] during the orthopaedic surgeries [31]. Moreover, a statistically significant reduction in the transfusion rate was also observed in the same cohort (−667 mL of blood transfused; 95% CI: −963, −370). No statistically significant differences were found regarding operative time and improve surgical condition.

There is ample evidence to suggest that regional anesthesia can be performed safely if antibiotic treatment of the infection has started prior to the placement of the regional block [32]. It appears that serious central nervous system infections such as arachnoiditis, meningitis, and abscess are rare after neuraxial anesthesia. Thus, an individualized decision must be made for performing neuraxial block in cases with infection. The anesthetic alternatives, advantages of neuraxial block, and risk of central nervous system infection, which theoretically may develop in the case of bacteremia, should be taken into account in making this decision. There is a paucity of literature that studies the risk of epidural abscess in patients undergoing surgery for PJI under regional anesthesia. In a recent study, Gritsenko et al [33] suggested that the risk of the central nervous system after neuraxial block during the removal of infected hip/knee implants is very small and that neuraxial anesthetics be used more liberally in this setting if there are no systemic signs of infection. They also recommended that no epidural catheters remain in place after the procedure. It appears that multiple neuraxial blocks within a short time period may be a risk factor for development of epidural abscess in patients with underlying PJI.

If neuraxial anesthesia is employed in patients undergoing treatment for PJI, every effort should be made to remove the epidural catheter soon after surgery. If a central nervous system infection occurs, prompt diagnosis and treatment of infection must be performed to avoid neurologic sequelae.

The study by Chang et al [34] found that the infection risk was 2.2 times lower with spinal anesthesia versus general anesthesia.

QUESTION 4A: What is the role for adjuvant technologies including cell salvage systems, reinfusion drains, bipolar sealers, and hemodilution for minimizing blood loss during surgery for PJI?

Consensus: There is no defined benefit for the use of cell salvage systems, reinfusion drains, bipolar sealers, and hemodilution for management of PJI.

Delegate Vote: Agree: 85%, Disagree: 8%, Abstain: 7% (Strong Consensus)

QUESTION 4B: What is the role for adjuvant technologies including cell salvage systems, reinfusion drains, bipolar sealers, and hemodilution for minimizing blood loss during TJA?

Consensus: There is no defined benefit for the use of cell salvage systems, reinfusion drains, bipolar sealers, and hemodilution during primary, unilateral TJA.

Delegate Vote: Agree: 80%, Disagree: 11%, Abstain: 9% (Strong Consensus)