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REVIEW

Pediatric Anesthesia Management for Post-Tonsillectomy Bleed: Current Status and Future Directions

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Abstract: After medical stabilization, several techniques are considered for anesthesia in the surgical intervention of post-tonsillectomy bleeding in children. Hypoxia during induction of general anesthesia occurs more frequently than aspiration for this population. While classical (apneic) rapid sequence induction and intubation with cricoid pressure still has a role, controlled rapid sequence induction and intubation that incorporates mask ventilation at low pressure (<12 cm H_2O) before direct laryngoscopy under a deep plane of anesthesia is a viable alternative for cases of slow venous bleeding. Supplemental oxygen delivery during laryngoscopy to permit apneic oxygenation is a future trend in management. While the routine administration of tranexamic acid during tonsillectomy has not been shown to be of benefit, it may have a role in post-tonsillectomy hemorrhage with further study.

Keywords: post-tonsillectomy hemorrhage, pediatric, postoperative emergencies, anesthetic management

Introduction

Post-tonsillectomy hemorrhage (PTH) is uncommon but remains the primary cause of reoperation and mortality after tonsillectomy in children. PTH is classified as primary bleeding (within the first 24h) and secondary bleeding (after 24h). The majority of PTH is secondary, peaking in incidence between postoperative days 5 and 7 when the fibrin clot separates from the tonsillar fossa.[1] Partly due to the different inclusion criteria and definitions in the various studies, the reported incidence of post-tonsillectomy bleeding varies. Overall, a mean rate of about 4.5% has been reported.[2] Since tonsillectomy is one of the most common surgeries performed on children, with greater than 500,000 cases yearly in the United States,[3] PTH requiring surgical intervention will be an emergency that most anesthesiologists will encounter in their clinical practice.

Search Strategy

A PubMed search for English language articles was undertaken to include articles published as of November 1, 2021, using the search string "post-tonsillectomy hemorrhage and anesthesia" and "pediatric." Initial search yielded 75 papers. Twenty five of these were excluded for including only adult patients or not discussing post-tonsillectomy hemorrhage. Seven papers were excluded for discussing mostly surgical technique. The remaining articles were retrieved and examined for this narrative review.

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Surgical and Patient Risk Factors

A recent study found that the risk factors associated with an increased risk of post-tonsillectomy bleeding included coblation and surgeon inexperience for primary bleeding, and age over 6 years for secondary bleeding.[4] However, a Cochrane database review published in 2017 was unable to demonstrate a difference in the rate of primary post-tonsillectomy hemorrhage when comparing coblation with other techniques. The risk of secondary bleeding may be slightly higher with coblation. However, the level of evidence and quality of evidence supporting this is low.[5] Partial (intracapsular) tonsillectomy may decrease the risk of post tonsillectomy bleeding when compared with total (extracapsular) tonsillectomy.[6]

In terms of patient factors, obesity has *not* been shown to be associated with increased PTH in adults or children.[7] Historically, surgeons have attempted to identify undiagnosed coagulopathy by obtaining preoperative coagulation studies in children scheduled for tonsillectomy. A meta-analysis including data from over 3000 patients found no difference in the rate of PTH when comparing patients with normal or abnormal preoperative coagulation studies,[8] and routine preoperative coagulation studies are no longer recommended if there is no personal or family history concerning for coagulopathy or if family history is not available (https://www.entnet.org/resource/clinical-indicators-tonsillectomy-adenoidectomy-adenotonsillectomy-in-childhood/).

In 2020, a case series that included a chart review of 250 children with PTH attempted to define the rate and identify characteristics of post tonsillectomy bleeding that would lead to a diagnosis of occult coagulopathy.[9] The authors found that even in children presenting with multiple episodes of post tonsillectomy bleeding, a diagnosis of coagulopathy was rarely uncovered. In the 250 children presenting with PTH, only three were diagnosed with an occult coagulopathy (13%). Two out of the three children diagnosed with a coagulopathy had normal labs, while the remaining one patient had a slightly elevated prothrombin time (PT). In children with a single post-tonsillectomy bleeding episode, no coagulopathies were identified despite 34.8% of them having an abnormal PT or activated partial thromboplastin time (aPTT). This finding was also not significantly different in the 42.2% of children having 2 episodes of post-tonsillectomy bleeding.

Anesthetic Management of Post-Tonsillectomy Hemorrhage: The Literature

The literature on anesthesia management of post-tonsillectomy hemorrhage is relatively sparse. Aside from short papers or sections in manuscripts on otolaryngologic emergencies[10–13,18] and a single center study from 1973,[14] only three recent papers have examined PTH and anesthesia. In particular, an anesthesiology education article on simulation training[15] and two single center retrospective studies have focused on the anesthetic management of PTH patients.[16,17] Anesthesia considerations at various phases of care in this patient population will be discussed to include preoperative preparation, induction techniques and future directions (Table 1).

Regardless of the actual *nil per os* time, patients with a bleeding tonsillar fossa are assumed to have a stomach full of swallowed blood. Post-tonsillectomy bleeds are rarely emergent arterial bleeds. More often they are venous oozing. Therefore, resuscitation is the primary therapeutic goal before surgical intervention.[18] Presentation may be dramatic with frank blood in the patient's mouth or bloody emesis. More often, the extent of blood loss will be difficult to accurately assess. Circulatory compensation will mask true extent of blood loss until 40% of blood volume is lost, at which point clinical signs of acute anemia such

Table 1 Anesthetic Preparation for Post-Tonsillectomy Hemorrhage

Preoperative Preparation
Prompt intravenous access and fluid resuscitation with isotonic fluids • In cases of difficult intravenous access, utilization of ultrasound guidance or intraosseous access as second line alternative • Point of care hemoglobin measurement until complete blood count resulted, crossmatch packed red blood cells and transfusion as indicated by clinical picture
Operating room setup
• 2 suction set-up • Endotracheal tubes of various sizes • Secondary intubation equipment such as video laryngoscope • Nasal cannula for apneic oxygenation during laryngoscopy
Induction technique
• Controlled RSII with gentle mask ventilation (< 12 cm H_2O) after induction of general anesthesia • Classical (apneic) RSII with cricoid pressure

Abbreviation: RSII, rapid sequence induction and intubation.

as pallor and tachycardia will become more apparent.[12] Intravenous access should be established and fluid resuscitation started promptly. A point of care hemoglobin testing can provide rapid results while a complete blood count, coagulation profiles and type and screen or crossmatch are arranged. Endotracheal tubes of varying sizes to accommodate airway edema and two suction systems should be available in cases of heavy bleeding in case one suction catheter becomes obstructed with blood clot.[10]

While inhalation induction in the lateral decubitus position has been described,[13,14,18] contemporary practice of pediatric anesthesia usually endorses intravenous induction. We will first explore the choice of classical (apneic) rapid sequence induction and intubation (RSII) versus controlled RSII with gentle bag-mask ventilation. The classical RSII consists of preoxygenation with 100% oxygen via face mask followed by administration induction agent while an assistant applies cricoid pressure, and rapid-onset muscle relaxant (succinylcholine or rocuronium), with rapid progression to intubation after an apneic period. Meanwhile, the controlled RSII technique involves preoxygenation, followed by administration of induction agent and nondepolarizing muscle relaxant without cricoid pressure, gentle controlled ventilation with pressure <12 cm H_2O and laryngoscopy when a deep plane of anesthesia and profound paralysis has been achieved.[19]

In the last 20 years, two single center retrospective studies have evaluated the anesthetic management of post-tonsillectomy bleeding in children. Fields et al[16] retrospectively studied 475 patients who presented for surgery with post-tonsillectomy hemorrhage at a tertiary care hospital from 1998 to 2005. Succinylcholine was used in most (88%) of patients and most (84.4%) underwent rapid sequence intubation with cricoid pressure (90%). Fields et al found that transient hypoxemia (SpO_2 <90%) was the most common adverse event, occurring in 9.9% of the total patients. About a third of the hypoxemic events occurred during induction and were not associated with difficult intubation. Difficult intubation was noted in 2.7% of patients, none of whom were difficult to intubate during their initial tonsillectomy. The authors suggested consideration be given for ventilation during RSII to address the hypoxemia seen during induction and to further analyze ways to decrease the incidence of emergence-related hypoxemia.

Kemper et al[17] examined the 110 surgical records of 103 children who presented to the operating room with post-tonsillectomy bleeding during a 12-year period from 2005 to 2017. Classical (apneic) RSII was utilized in 22 surgeries, while controlled RSII (with bag mask ventilation) was used in 88 cases. While neither group had significant pulmonary complications, the controlled RSII group had less severe hypoxemia, less hypertension and better view on direct laryngoscopy than the classical RSII group. Kemper et al put forth the controlled RSII technique as a viable option for this patient population.

Aspiration Risk

While these two studies examined pediatric post-tonsillectomy patients, we will next examine some associated issues and controversies: pulmonary aspiration risk and the use of cricoid pressure in children. Pulmonary aspiration is one of the most dreaded complications for the anesthesiologist. Warner et al[20] examined all cases of pulmonary aspiration in children under 18 years of age from 1985 to 1997 at the Mayo Clinic. Of the 63,180 general anesthetics performed in this 12-year time period, 24 patients suffered pulmonary aspiration (1:2,632 or 0.04%). The majority of these cases occurred during the induction of anesthesia. Warner et al found that pulmonary aspiration occurred much more frequently in emergency surgery than elective surgery: 1:373 versus 1:4544. Fifteen out of the 24 patients who did not show respiratory symptoms in the first 2 hours after anesthesia did not later develop pulmonary complications. No patients died due to their aspiration event. None of the 24 cases of pulmonary examination in Warner et al's study involved post-tonsillectomy hemorrhage.

Pfaff et al's[21] study of the Wake Up Safe database over a 7-year period showed a perioperative aspiration incidence of 0.006%, with 2 deaths among the 135 aspiration events. Both of these deaths occurred in patients with significant co-morbidities and were not PTH. Patients undergoing emergency surgery were twice as likely to aspirate. Although this study did not analyze by case type, 6% of aspiration events were due to blood or secretions in the airway. In an otolaryngologic paper that specifically examined fatal PTH events, aspiration did play a significant role. In Windfuhr et al's study of 29 patients who died after post tonsillectomy bleeding, eighteen of whom were children, aspiration of blood contributed to the lethal outcome in almost half of the cases.[22] The aspiration events were not necessarily perioperative but due to aspiration of blood from the PTH itself.

The current trend toward controlled RSII over classical RSII is supported by studies not exclusive to the post-

tonsillectomy hemorrhage population. Gencorelli et al's[23] benchmark study of 1070 children who underwent RSII from 2001 to 2006 at a single institution showed that transient hypoxemia occurred in 3.6%, with severe hypoxemia (SpO_2 <80%) more likely in children who weighed less than 20 kg. One patient had emesis without signs of pulmonary aspiration following esophageal intubation. Neuhaus et al's[24] study of controlled RSII in 1001 children showed that moderate hypoxemia (SpO_2 80–89%) occurred in 0.5% of cases and severe hypoxemia (SpO_2 <80%) occurred in 0.3%. One gastric regurgitation was observed without signs of pulmonary aspiration. These two studies of complementary groups showed that in both classical RSII and controlled RSII, hypoxemia was the most common complication, but to a much less extent in the controlled RSII population (3.6% vs 0.8%). Meanwhile, the risk of gastric regurgitation was not increased in the controlled RSII group. The general risk of pulmonary aspiration remained low for both types of induction.

Cricoid Pressure

Another feature of classical RSII that has been accepted as dogma for many years is cricoid pressure. As the only cartilaginous structure in the upper airway that is a complete ring, mistakenly exerting pressure on another cartilage, such as the trachea or thyroid cartilage, may lead to upper airway distortion or obstruction. The force needed to prevent passive gastric reflux is 30 to 40 N but only after loss of consciousness since any force above 20N in an awake patient is poorly tolerated. The recommendation is to exert 30N of force on the cricoid cartilage since 40 N may cause distortion of the upper airway during laryngoscopy.[25] Moynihan et al[26] found that in pediatric patients properly applied cricoid pressure was effective in preventing gastric insufflation during bag mask ventilation up to a peak pressure of 40 cmH_2O with and without muscle relaxants. The benefit was particularly seen in paralyzed patients who tended to insufflate air into their stomachs at lower pressures. While theoretically of benefit, proper practice of cricoid pressure is far from ubiquitous.

Meek et al's[27] study of anesthesia assistants at a single British institution showed widespread lack of knowledge about proper force required in cricoid pressure and observed poor technique in those tested. In fact, some anesthesiologists have argued that cricoid pressure should not be widely used in pediatric anesthesia for this reason and others: even with preoxygenation, cricoid pressure in the classical RSII technique presupposes intubation after about a minute of apnea after induction, which is tolerated in adults and teenagers but often leads to hypoxia in younger children; incorrect location or excessive force distorts airway anatomy, making intubation more time consuming and difficult; and a "crash" sort of induction has been associated with hypotension and bradycardia in children. These authors emphasized achieving an adequate plane of anesthesia, confirmation of neuromuscular blockade and gentle controlled mask ventilation in order to provide optimum intubating conditions and avoid adding additional stress that can lead to error.[19,28,29]

Future Directions

Anesthetic Techniques

While hypoxia has been shown to be the most common complication of both classical and controlled RSII for exploration of post-tonsillectomy hemorrhage, utilization of supplemental oxygen during laryngoscopy is not a widespread practice. Successful use of this technique depends on preoxygenation, a patent airway and continuous oxygen delivery. Low-flow oxygen via nasal cannula to provide apneic oxygenation during laryngoscopy may have a valuable role in the operating room, particularly for difficult intubations, in younger children and infants, or in cases involving trainees who may take longer to secure the airway. Successful adaptation of this low-risk technique of apneic oxygenation in pediatric anesthesia will require continuing dissemination at national meetings, adaptation in the difficult airway algorithm and deliberate incorporation into everyday practice.[30] Simulation can be another useful educational tool for reinforcing these techniques in a PTH scenario and in trouble-shooting challenges that may arise such as difficult intravenous access.[15] Timely utilization of ultrasound guidance to assist in peripheral intravenous access when it proves challenging and facility in using the infrequently utilized intraosseous access may save valuable time in definitively treating PTH.[31,32]

Nonsteroidal Anti-Inflammatory Drugs

The use of ibuprofen to control postoperative pain after tonsillectomy is becoming more popular in part because of the desire to avoid prescribing opioid to young children with sleep disordered breathing. In 2011, the American Academy of Otolaryngology included a strong recommendation for use of ibuprofen or

acetaminophen or both for pain control following tonsillectomy in children. This recommendation was maintained in the 2019 update. Some concern has been raised for increased risk of bleeding because of ibuprofen's mechanism of action. Ibuprofen is a nonselective blocker of cyclooxygenase (COX), which decreases the production of inflammatory cytokines and blocks the formation of thromboxane A2 which inhibits the platelet aggregation cascade. A systematic review and meta-analysis in 2013 looked at different nonsteroid anti-inflammatory drugs (NSAIDs) and found an increase in bleeding that was not statistically significant.[33] A Cochrane Database review was initially published in 2005 and updated in 2010, 2012 and 2013. The latest update included 15 studies and 1101 patients. NSAIDs caused a non-significant increase in bleeding requiring surgical intervention (OR 1.69, CI 95% 0.71–4.01).[34] They did not increase the risk of bleeding requiring non-surgical intervention (OR 0.99 CI95% 0.41–2.4). There was insufficient evidence to exclude an increased risk of bleeding when NSAIDs were used for elective tonsillectomy and adenoidectomy. However, in a subgroup analysis, ketorolac suggested an increase in the risk of bleeding requiring a surgical intervention (OR 3.82 CI 95% 1.03–14.10) but the statistical test that looks for differences between subgroups was not statistically significant (p = 0.1). Stokes et al's meta-analysis[33] looking exclusively at ibuprofen found 12 articles looking at use of ibuprofen vs control and risk of bleeding. Increased risk of PTH with ibuprofen was noted (OR 1.38, CI 1.11–1.72). Limitations included some studies not controlling for age, varied surgical technique, some studies not confirming if patients actually took the prescribed ibuprofen, and doses potentially not controlled.

A multicenter randomized double-blind noninferiority trial including 741 children in 4 tertiary medical centers undergoing tonsillectomy or tonsillectomy with adenoidectomy. The risk of severe bleeding (requiring a surgical intervention) during 14 postoperative days was compared between patients receiving acetaminophen or ibuprofen.[35] The noninferiority margin was set at 3%. The rate of severe bleeding was 1.2% in the acetaminophen group and 2.9% in the ibuprofen group (difference, 1.7%; 97.5% CI upper limit, 3.8%; $P = 0.12$ for noninferiority) not excluding a higher risk of severe bleeding in the ibuprofen group.

In terms of intravenous NSAIDs, ketorolac is rarely used for fear of increased risk of PTH. However, a retrospective case examining 1322 patients under 18 years of age undergoing tonsillectomy between 2013 and 2017 found that intraoperative ketorolac was not associated with increased bleeding. Moreover, ketorolac decreased postoperative opioid requirement.[36]

Tranexamic Acid

The antifibrinolytic tranexamic acid has been shown to decrease bleeding in a wide range of medical and surgical settings.[37] Regarding its use during tonsillectomy, tranexamic acid was shown to decrease blood loss following tonsillectomy but did not impact the incidence of PTH. However, most of the studies included in this review article were published prior to 1980.[38] Additionally, a large database study comparing over 90,000 patients who had received tranexamic acid during tonsillectomy to a control group did not find a difference in risk of reoperation or blood transfusion. Almost 40% of the patients included in this study were less than 15 years old.[39] Tranexamic acid has been reported to stop secondary PTH when administered by nebulization in the emergency department in a 3-year-old patient.[40] Although no benefit could be demonstrated with routine administration during tonsillectomy, further investigation is necessary to assess tranexamic acid's potential use during PTH either by nebulization in the emergency department or as an adjunct when patients are required to return to the operating room.

Conclusion

Although an infrequent event, PTH can result in catastrophic complications. While a variety of anesthetic techniques including inhalation induction have been utilized, actual aspiration risk during induction for most pediatric patients presenting to the operating room for surgical management of PTH is low and outweighed by the risk of hypoxia. Conventional wisdom dictating classical (apneic) rapid sequence induction and intubation with cricoid pressure has been challenged by several studies that have shown controlled ventilation at <12 cm H_2O before direct laryngoscopy under a deep plane of anesthesia is a viable alternative that should be considered in this patient population. Likewise, supplemental oxygen delivery during laryngoscopy to permit apneic oxygenation is a future trend in management. Patient factors such as occult coagulopathies rarely contribute to PTH. However, tranexamic acid may have a role in supplemental management of PTH with further study.

Disclosure

The authors report no conflicts of interest in this work.

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