Title: Massive Hemorrhage With Nuss Bar Removal and Massive Transfusion Protocol in a Tertiary Care Center

Moderators:

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Goals

1. Pre-operative evaluation: Learners will discuss the pre-operative factors that could identify patients at higher risk from Nuss Bar Removal and how it could influence anesthetic management.
2. Positioning: Assess the importance of arm position during Nuss Bar removal procedure. Arms can be out to the side on arm boards or tucked at patients side. Learners will discuss pros and cons of both of these positions.
3. Access: Learners will discuss the importance of adequate access. Necessity of a central venous line (CVC), arterial line (A-Line), and number of peripheral intravenous lines (PIV's) will be discussed.
4. Massive transfusion: Learners will discuss the basis behind massive transfusion protocols along with potential adverse effects.
5. Rh+ ramifications in females – Learners will discuss the treatment and management of Rh+ transfusion in Rh- females.

Description

An eighteen year old healthy female who underwent an uncomplicated placement of 2 Nuss bars three years prior presented for a Nuss bar removal. She had no other medical problems, took no medications, and had no anesthetic complications from her only procedure. Once in the operating room, she was positioned with her arms out on boards and a 20G PIV was placed in her left hand. Anesthetic induction occurred without any issues, and the surgical removal of her bars proceeded without incident until the second bar was freed. Upon extraction of the second bar, massive hemorrhaging occurred through both the right and left incisions. Help was immediately called for to assist with establishing access for the subsequent massive blood transfusion and fluid resuscitation. With three anesthesiologists in the operating room, a 16G PIV was placed in the right hand, a left radial arterial line was placed, and a right internal jugular central line was placed within 10 minutes of the hemorrhage. A rapid transfuser was attached to peripheral 16G IV and used to assist in the resuscitative effort, and the massive transfusion protocol was instituted. A clamshell incision was made, and with the assistance of a cardiothoracic surgeon, the source of hemorrhage was quickly identified and corrected. The resuscitative effort was ultimately successful, however, during the massive transfusion, Rh+ platelets were given to our Rh- patient. Unfortunately, despite the low amount of red blood cells

that are present in platelet transfusions, there is enough Rh+ hemoglobin to result in Rh sensitization in the Rh- female. Of course, without treatment, this could cause pregnancy complications in the future. This case highlights the known but underreported complications associated with Nuss Bar removal, and it specifically addresses the management of these complications. Also unique to this case is the management of massive blood transfusion and Rh protocol creation in a tertiary pediatric care center.

Case history:
An 18 year old, 53 kg female, was scheduled for a Nuss Bar Removal. A 20G PIV was placed in the left hand, after which she was intubated and positioned without incident.

Questions:

Are any pre-operative laboratory values indicated in this uncomplicated Nuss Bar removal? Assuming this is an otherwise routine case, what vascular access would be warranted? Is there any utility for a double lumen endotracheal tube? Is an inpatient stay warranted for this procedure?

Case history (continued):
No pre-operative laboratory values were obtained, as this patient was otherwise healthy. Because of the short duration of the procedure, and no evidence of bar misplacement, a 20G PIV was deemed to be sufficient for induction and maintenance of the anesthetic. A double lumen endotracheal tube would not be required for this case, as there was no thoracoscopic component to the procedure. Essentially, this was a "blind" procedure, consisting of suture removal, straightening of the metallic bars, and manual extraction from the incisions. Because there are no major structural changes to the chest wall, this procedure can routinely be done on an outpatient basis.

Questions:
Is there any specific anesthetic technique that would prove to be advantageous for this case? Upon removal of the second Nuss Bar, and observation of hemorrhage, what should your next steps be? What is the utility of having a massive transfusion protocol in place? What does it mean to "stay ahead" in relation to the transfusion of blood products? What is the ideal ratio for blood transfusion?

Case history (continued):
Aside from avoding Nitrous Oxide in case of inadvertent entrance into the thoracic space, there is no specific anesthetic technique that would be more adventageous to another. Upon the observation of massive hemorrhage, several actions should occur rapidly. 1) Calling for help in the operating room is imperative, to allow for rapid stabilization of the patient; 2) Activation of the massive transfusion protocol will allow for adequate blood products to be available in the room; 3) Constant communication with the surgeon will allow for continuous reassessment of the ongoing blood loss; 4) Obtaining invasive monitoring (arterial line, central line), and large peripheral intravenous access is necessary to assist in resuscitation and further perioperative

management.

The utility of a Massive Transfusion Protocol (MTP) is to help with the prioritization of blood bank resources and management. When activated, the blood bank should divert all resources to assisting that particular (and most critical) patient. The ratio of products delivered to the patient requiring the MTP may vary between institutions, ranging from PRBC:FFP:Platelet ratio of anywhere from 1:1:1 to 3:1:1. The most promising studies have stemmed from combat military operations, which suggest that in massive hemorrhage, early use of the 1:1:1 ratio improves overal morbidity and mortality in patients.

In centers that do not have an MTP in place, discussions with the pathologist running the blood bank can be invaluable in a crisis situation. With the anesthesiologist acutely aware of the needs of the patient, and the pathologist acutely aware of the resources of the blood bank, the two can more easily coordinate a care plan to best suit the situation at hand. Availability of resources, alternatves to current care, and effective solutions for best care can quickly and easily develop the best plan for the patient in jeopardy. In centers such as these, a "stay ahead" order is put in place for children that are known to be undergoing procedures with major blood loss. This allows the bank to ensure that there are alwas some "X" additional units availiable for any given blood product (RBC's, FFP's, PLT's, Cryo) to be ready for immediate delivery to the critically ill patient. Unlike MTP's, these "stay ahead" orders are much more variable based on providor preferences, but is still better than having no plan in place for the tremeant of masive transfusion.

Questions:
What are possible causes of this hemorrage? Are there any data you can collect to help narrow the search of the bleeding orifice? Once bleeding is conrolled, what studies would be helpful in futhering your management? Should she be extubated at the end of the case? Where would her post-operative recovery best be performed?

Hemorrhage can occur from tissue injry with subsequent oozing from capillaries (most unconcerning) all the way to direct transection of the IVC Aorta. In our patient, the hemorrhage was brisk, bilateral, and bright, three qualifiers that strongly concerned us about an arterial source. The resultant trend towards tachychardia and hypotension confirmed that there was continued and ongoing bleeding somewhere in the chest.

While the IVC, Aorta, Pericardiam, and Myocardium are seen on the initial thoracoscopic approach for placment and avoided, this same technique is not used on removal, where the bars are simply exposed, unbent, and extracted. In this patient, the second extraction resulted in massive bilateral intrathoractic hemorrhage.

Upon making a clamshell incision, the source of bleeding was shortly found to be the left interiror mamillary artery, which had ben under the compression of the bar prior to its removal. By removing the bar, the artery ruptured, and it resulted in the catastrophic presentation described here. The surgeon was notified, who immediately called for assistance from the Cardiovascular Surgery team, and we alerterd our anesthesiologists to a possible code situation

in the operating room.

After bleeding was controlled, several laboratory and clinical values can be used to help assess the adequacy of resuscitation. An arterial blood gas is an excellent way to uncover any uncorrected acid/base abnormalities, confirm an adequate level of hemoglobin, and ensure that there are no severe electrolyte derangements. After a massive transfusion of blood products, however, one other key concern is brought to the forefront – coagulopathy. While there is no one test to determine if a patient is coagulopathic, getting a platelet count, fibrinogen level, PT/PTT, and INR, along with a thromboelastogram can be very insightful on what the patient has, and what the patient may need next.

Because of her clamshell incision, unexpected massive blood loss, and unclear neurological status, extubating her at the end of the case is questionable. During the entire hemorrhage, her blood pressure was no longer than 50mmHg systolic for 30 seconds. While it is possible she may have suffered a neurological insult in that short of a time, our thought was that pain control would be a more difficult prospect following the large incision. We decided to keep her intubated overnight an allow for adequate sedation, ensure no further blood products were required, with the goal of extubating her the next morning.

She was monitored post-operatively in the PICU.

Questions:

What are common complications of Nuss Bar Removals? What is the protocol for the treatment of an Rh sensitized mother who has not yet had children?

Although underreported, blind removal of Nuss Bars does have significant risks associated with it. While there are more minor risks (pneumothorax/hemothorax that requires chest tube drainage), more serious issues can happen, such as flipping of the bar, pulmonary lacerations, cardiac contusions and perforation, and inadvertent and inappropriate manipulation of cardiopulmonary structures in patients with congenital heart disease.

Protection from Rh immunication in a patient that has been exposed to Rh+ Red Blood Cells can be done by administering Rhogam, at a dose of >20 µg per mL of Rh+ Red Blood Cells transfused, within 72 hours of transfusion. Of note, a single dose of Rhogam has 300 µg of Anti-D antibodies, or enough to reverse 15cc of blood. That would me for a 250cc PRBC transfusion, 17 vials of Rhogam would be required to prevent Rh sensitization, and possible fetal complications with pregnancy. Although a seemingly trivial amount of red blood cells is seen in platelet transfusions (2 ccs or less), it takes less than 100 µL to sensitize an Rh- female and cause catastrophic complications in the future. For this reason, if a patient has received an Rh+ Platelet transfusion, it is recommended that she receive one does of the 300 µg of Rhogam, to ensure complete coverage and elimination of the Rh+ Sensitization Phenomenon.

Discussion

This case brings up several unique challenges. Often times, there are cases such as these that are "routine" in nature, taking up small portions of our day. In many instances, a balanced anesthetic technique with a single peripheral IV is adequate for safely guiding these patients through surgery.

With the known but rare rate of complications that occurs with Nuss Bar removal, this PBLD aims to harbor a discussion on the best management of these patients. Should we place invasive monitors, two large peripheral IV's, ask for blood warming devices, rapid transfusion devices, and have blood in the room prior to induction? Or could these cases proceed with a single IV and arterial line, while allowing the arms to be extended in case further access should be required.

Hospital equipment (rapid transfusion equipment, blood product, invasive monitors), resources (blood bank, laboratory), and testing (CBC, Type and Cross, Coagulation Studies) all increase charges to both the hospital and the patient. It is worth considering whether applying an extremely conservative strategy to all patients undergoing a Nuss Bar removal after a catastrophic event such as the one discussed today is the rational next step.

Unfortunately, there is no right answer. By placing invasive monitoring in every patient undergoing Nuss Bar removals, there is a chance that the anesthetic setup could take twice as long as an uncomplicated surgery. On the other hand, being underprepared can result in the loss of a patient's life.

Through advanced imaging and communication with the surgeon, these types of cases should be able to be greatly reduced in the future. High density CT scans can show erosion (or lack thereof) of the bars into vascular structures. Thoracoscopic guidance on more complex patients during Nuss Bar Removal can be helpful in identifying unfavorable conditions prior to extraction, and constant communication with the anesthesiologist during these studies can help improve patient safety. By stratifying patients into high and low risk categories, we can help optimize the amount of resources being expended on patients that do not require them, help improve patient safety by being aware of the known complications of Nuss Bar procedures, and be adequately prepared to treat any complications as they arise. At the time of this PBLD, our institution now recommends having 2 large PIV's and a Radial Arterial Line in place prior to commencement of the Nuss Bar Removal.

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