CASE STUDY

CONTENTS

Hemorrhagic shock in the late postoperative period after the Nuss method procedure – case study

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ABSTRACT

Aim: The study aims to describe a clinical case and its management in the Hospital Emergency Department of a seventeen-year-old boy with posttraumatic internal hemorrhage into the pleural cavity during the late postoperative period following Nuss surgery.

Materials and Methods: This paper presents a clinical case of a 17-year-old patient who was initially admitted to the Emergency Department (E.D.) of the District Hospital named after John Paul II in Bartoszyce, with a history of surgical treatment of pectus excavatum, after blunt chest trauma and in result hemorrhagic shock.

Conclusions: Although low-energy injuries usually do not cause significant health damage, the overall clinical impression, the ABCDE assessment, and a detailed patient history are crucial. Information about previous surgical procedures can be invaluable in identifying the source of an acute health threat. With access to EBM, the analysis should consider all possible causes - from the most common, through the rarest, to those not described in the medical literature but potentially possible.

KEY WORDS: hemorrhagic shock, nuss method, ED, DCS

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INTRODUCTION

Hemorrhagic shock is a subtype of hypovolemic shock that develops as a consequence of whole blood loss and is responsible for approximately 40% of trauma-related fatalities [1]. Blood extravasation accounts for up to 80% of deaths occurring during surgery in patients with severe traumatic injuries [2] and contributes to nearly 50% of trauma-related deaths within the first 24 hours following injury. In adults, blood loss of less than 750 mL (approximately 15% of the circulating blood volume) typically on physical examination hypotension, tachycardia or altered mental status do not reveal or only minor changes, however the general condition is usually unchanged [3]. Early recognition of hemorrhagic shock is critical, as is the prompt initiation of the damage control surgery (DCS) approach. DCS specifically encompasses, among other measures, rapid control of hemorrhage, restoration of hemostasis, and minimization of secondary tissue injury. This paper presents a clinical case of a 17-year-old patient who was initially admitted to the Emergency Department (E.D.) of the District Hospital named after John Paul II in Bartoszyce, with a history of surgical treatment of pectus excavatum, after blunt chest trauma and in result hemorrhagic shock.

Pectus excavatum (PE) is a deformity that develops due to abnormal attachment of the ribs to the sternum. PE originates from an embryological developmental disorder, with its pathogenesis beginning around the 35th day of gestation, continuing throughout pregnancy, and ultimately concluding with ossification of the ribs during adolescence. As a result, the sternum is pulled inward, creating a characteristic depression in the chest wall. PE is the most common congenital chest wall anomaly, occurring approximately five times more frequently in boys than in girls [4]. A genetic hypothesis has been proposed, as the condition frequently occurs in individuals whose relatives have presented with similar disorders. The problems arising from pectus excavatum are primarily cosmetic in nature; however, in some patients, deformity may cause respiratory difficulties, chest pain, or reduced exercise tolerance. This can lead to emotional and psychological disturbances in patients, particularly in adolescents. The Nuss procedure is the gold standard for the treatment of pectus excavatum. The procedure, developed by Nuss in 1988, is used to correct funnel

Fig. 1. Nuss bar implanted in the patient's wall chest: A – frontal view, B – lateral view

chest, a deformity of the sternum and adjacent costal cartilages in which these structures are depressed inward. It involves the insertion of a curved metal plate beneath the sternum, which, after rotation within the thoracic cavity, allows correction of the sternal deformity. The corrective plate is introduced through bilateral incisions on the sides of the chest, under thoracoscopic guidance. In Poland, the first Nuss procedure was performed in 1998 by the team led by Professor Janusz Bohosiewicz in Katowice [5]. Figure 1 shows Nuss bar implanted in the patient's wall chest

Surgeries performed at surgical centers specializing in PE treatment yield excellent outcomes. According to various sources, recurrences occur in 2–10% of patients undergoing surgery [6]. Some studies have shown that nearly 95% of patients are satisfied with both the aesthetic appearance and functional aspects. The incidence of complications (both severe and mild) ranges between 15 to 20%. Early postoperative complications (within the first month) include pneumothorax, pleural effusion, pneumonia, hemothorax, pericarditis, and surgical site infection, while late complications (occurring more than a month postoperatively) include: prolonged chest pain and – rarely – overcorrection of the deformity resulting in 'pigeon chest', displacement of the plate or rib fracture, and hypertrophic scarring.

The primary postoperative recommendation is that patients should refrain from engaging in strenuous physical exertion for approximately six weeks. Following this period, they may generally resume aerobic activities, such as football or basketball; however, until the corrective metal bar is removed, participation in high-contact sports, including American football or ice hockey, is contraindicated. Such high-contact activities can be safely resumed only after approximately two years, once the desired shape of the sternum has been achieved [7].

AIM

The study aims to describe a clinical case and its management in the Hospital Emergency Department of a seventeen-year-old boy with posttraumatic internal hemorrhage into the pleural cavity during the late postoperative period following Nuss surgery.

MATERIALS AND METHODS

This paper presents a clinical case of a 17-year-old patient who was initially admitted to the Emergency Department (E.D.) of the District Hospital named after John Paul II in Bartoszyce, with a history of surgical treatment of pectus excavatum, after blunt chest trauma and in result hemorrhagic shock.

CASE REPORT

On 5 May 2024, at 20:45, a seventeen-year-old boy presented to the E.D. with his mother, complaining of breathing difficulties. The boy reported that the problems had occurred while playing with friends approximately 30 minutes before the hospital visit. The patient's mother reported that he had never received long-term medical treatment, was not on any regular medications, and had no known allergies. She also stated that he had eaten dinner at 18:00. On initial assessment of vital signs according to System for Managing Patient Service Modes in the Hospital Emergency Department (TOPSOR) at 20:47, the following values were recorded. The patient was triaged as a yellow priority in Emergency Severity Index (ESI) (Table 1).

At 20:55, a reassessment of the vital signs was performed using the modified Early Warning Score (EWS) on the observation ward (Table 2).

During the initial assessment, pallor of the skin and a forced body position were observed. When asked

Table 1. Vital signs , hour 20:47

Hour	AVPU	BP syst. (mmHg)	BP diast. (mmHg)	Heart rate (/min)	Resp. rate (/min)	SpO2, k (%)	Oxygen l/min	Body. Temp. (°C)	NRS	Priority ESI
20:47	A	113	69	68	16	100	On room air	36,4	0/10	3

Table 2. Vital signs , hour 20:55

Hour	AVPU	BP syst. [mmHg]	BP diast. [mmHg]	Heart rate [/min]	Resp. rate [/min]	SpO^2 [%]	Oxygen [l/min]	Body Temp. [°C]	NRS	Glycemia [mg%]
20:55	A	110	73	65	16	99	On room air	36,4	0/10	137

Table 3. Blood count, hour 21:02

Hour	Leukocyttes [10^3/µl]	Neutrocytes [10^3/µl]	Lymphocytes [10^3/µl]	Erythrocytes [10^6/µl]	Hemoglobin [g/dl]	Hematocrit [%]	Platelets [10^3/µl]
21:02	9.60	5.38	3.54	4.35	13.5	39.2	268

Table 4. Vital signs , hour 21:58

Hour	AVPU	BP syst. [mmHg]	BP diast. [mmHg]	Heart rate [/min]	Resp. rate [/min]	SpO_2 k [%]	Oxygen [l/min]	Body. temp. [°C]	NRS
21:58	A	61	34	81	28	100	2	36,4	0/10

Table 5. Blood count, hour 22:00

Hour	Leukocytes [10^3/µl]	Neutrocytes [10^3/µl]	Lymphocytes [10^3/µl]	Erythrocytes [10^6/µl]	Hemoglobin [g/dl]	Hematocrit [%]	Platelets [10^3/µl]
22:00	15.27	12.30	1.82	3.46	10.8	31.4	228

Table 6. Vital signs , hour 22:20

Hour	AVPU	BP syst. [mmHg]	BP diast. [mmHg]	Heart rate [/min]	Resp. rate [/min]	SpO2 k [%]	Oxygen l/min	Body. Temp. [°C]	NRS
22:20	A	100	62	85	22	99	2	36,2	0/10

about previous surgeries or hospitalizations, the mother reported that approximately one year prior, her son underwent surgery to correct his funnel-shaped chest. When asked about the possible cause of the injury, the mother explained that during play, a friend standing behind him squeezed her son tightly in the chest area.

On physical examination:

A – Airways patent and unobstructed

B – Breathing: respiratory rate 16/min, unlabored, no accessory muscle use; SpO_2 99%/ FiO_2 0.21; auscultation reveals normal, symmetrical vesicular breath sounds

C – Steady heart rate, 72/min with normal tension, skin pale and

dry; capillary refill 3 seconds; jugular veins normally filled.

D – no abnormalities, GCS 15

E – abdomen soft, no pathological resistance, no signs of peritonitis, no

visible external injuries; normothermic

An intravenous line was secured, and blood samples were taken for additional investigations, including full blood count with smear, CRP, creatinine, urea, ALT, AST, serum amylase, and troponin. The patient was started on analgesic therapy and stress ulcer prophylaxis. An ECG showed a regular sinus rhythm at 80/min, with an intermediate cardiac axis and repolarisation abnormalities present. An eFAST ultrasound was performed, which revealed inconclusive findings in the right pleural cavity. A chest X-ray was planned. Initial full blood count results showed no abnormalities (Table 3).

At the X-ray department, the patient suddenly felt faint upon being positioned upright; his condition improved rapidly when placed in the supine position. Oxygen was administered via nasal cannula at a flow rate of 2 L/min. A decision was made to forgo the chest X-ray and to extend the diagnostics to include a contrast-enhanced chest CT scan, which revealed an excessive amount of free fluid in the right pleural cavity and metal artefacts from the chest stabilizer.

Given the above situation, the patient was moved to the resuscitation and treatment area, and a reassessment of the parameters according to the EWS scale was performed (Table 4).

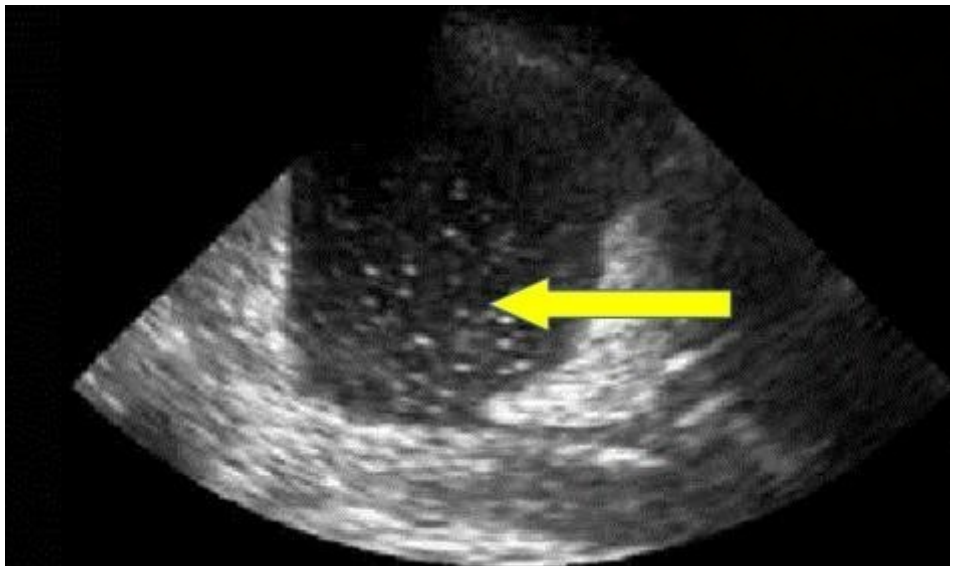

Fig. 2. Swirling sign in right pleural cavity (yellow arrow indicates visible movement of blood particles within a fluid collection)
Source: Own materials

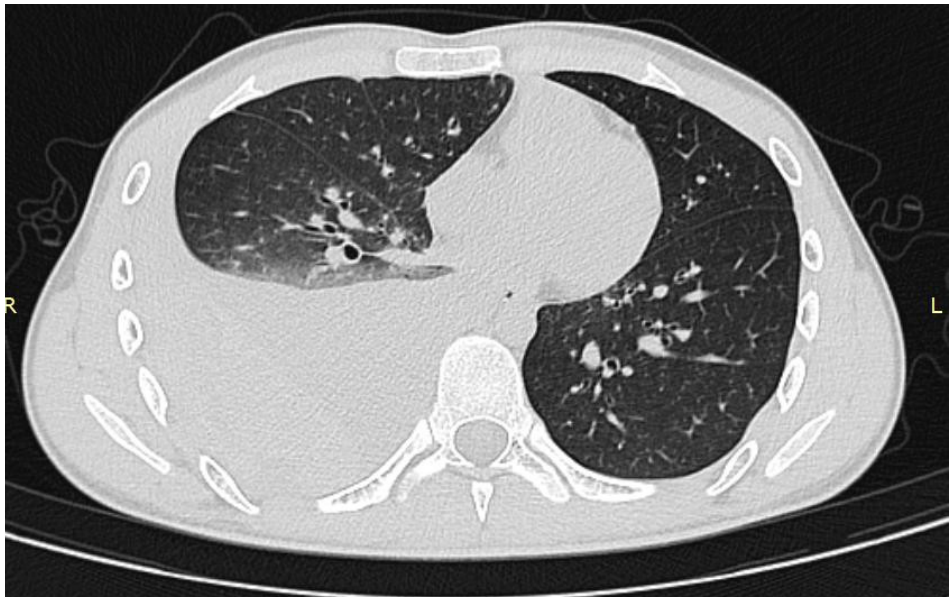

Fig. 3. CT of the chest with right hemothorax
Source: Own materials

Hypovolemic shock was suspected. Fluid resuscitation was initiated with 250 ml aliquots of warm balanced crystalloids (38°C), tranexamic acid 1 g i.v. over 10 minutes, followed by 1 g over 8 hours via continuous infusion, and warmed Ringer's lactate solution. Blood was taken for blood group determination and compatibility testing, and 2 units of PRBCs and 2 units of fresh frozen plasma were ordered. A repeat full blood count was also requested. Thermal comfort was ensured by maintaining body temperature above 36 °C. A consultation with the on-call general surgeon was also requested. Due to the presence of free fluid in the pleural cavity on chest CT and suspicion of active bleeding, a repeat bedside ultrasound was performed, revealing a swirl sign suggestive of the above diagnosis.

A diagnostic thoracentesis of the right pleural cavity was performed under ultrasound guidance, yielding bright red aspirate.

On follow-up blood count, features of anemia were noted (Table 5).

Due to the unavailability of O Rh (-) blood in the blood bank, 1 unit of group-compatible PRBCs and 1 unit of FFP were transfused, resulting in the following vital signs according to the modified EWS (Table 6)

During the transfusion of blood products, a telephone consultation was held with a physician from the Department of Pediatric Surgery and Urology at the Provincial Specialist Children's Hospital in Olsztyn. After presenting the clinical condition and the results of additional tests, it was decided to refrain from inserting a right pleural cavity drain and to transfer the patient as a matter of urgency. The estimated transport time was 60 minutes. While awaiting transport, a repeat full blood count was requested, and transfusion of another unit of PRBCs was started, which was continued during transport. At 23:26, the patient, in a moderately severe but stable general condition, was transported to the receiving hospital by interhospital transfer under the supervision of the on-call physician.

During transport, the chest CT report was received: a significant amount of heterogeneous fluid (blood) was present in the right pleural cavity, measuring up to 75 mm from the diaphragm towards the lung apex. Administration of contrast revealed active extravasation into the pleural space from the region of the anterior chest wall just above the diaphragm (possible injury to the intercostal artery? diaphragmatic artery? internal thoracic artery?). Accurate assessment was limited by metallic artefacts from the stabilizer. Posttraumatic diaphragmatic injury could not be excluded. There was a slight leftward mediastinal shift due to pressure from the hematoma. The CT report was communicated to the receiving physician at WSDD (Fig. 3).

Further information was obtained after an official request to the WSSD in Olsztyn with the written consent of the patient's mother.

The patient, in a critically stable condition, was admitted to the Pediatric Emergency Department in Olsztyn (PED). Based on the diagnostic evaluation performed at the Bartoszyce ED, he was urgently indicated for an exploratory thoracotomy. During this procedure, the right pleura was opened in the intercostal region, and a plate was removed, revealing a bleeding internal thoracic artery. After securing the patient, hemostasis was achieved, blood clots were removed from the right pleural cavity (approximately 800 mL), and a size 24 chest drain was inserted below the incision line. Bleeding on the left side was also excluded. During the procedure, the patient required transfusion of 4 units of packed red blood cells (PRBC) and 2 units of fresh frozen plasma (FFP). In addition, 1500 IU of Beriplex (prothrombin complex concentrate), 2 g of Riastap (human fibrinogen), and 4 mg of Novoseven (recombinant activated factor VII) were administered, and circulatory support was provided with a norepinephrine infusion. The patient was admitted to the Pediatric Intensive Care Unit (PICU) in a stable, severe condition with Richmond Agitation Sedation Scale (RASS) agitation/sedation score of 4. A postoperative chest X-ray showed signs of bilateral pneumothorax. Suction drainage to the left pleural cavity was performed. Intravenous antibiotic therapy was initiated and modified based on the clinical condition and laboratory test results. Due to anemia, thrombocytopenia and circulatory disorders, blood transfusions and blood products were administered repeatedly. Anticoagulant prophylaxis was introduced.

On the third day after admission, a repeat chest CT scan was performed, which revealed no evidence of contrast extravasation, bilateral pneumothorax, a small amount of fluid in the pleural cavities, and consolidation of the pulmonary parenchyma in the lower lobe of the right lung. During the hospitalization in the PICU, gradual clinical improvement was observed, allowing discontinuation of amine vasopressors and analgosedation. Following extubating, respiratory support was temporarily provided via high-flow nasal cannula (HFNC).

One week after admission, the patient, with stabilized respiration, was transferred to the Pediatric Surgical and Urological Ward, where the chest drains were removed. Conservative management was continued, not requiring surgical intervention. Following follow-up imaging and laboratory tests, which revealed no abnormalities, the patient was discharged home in good general condition, with recommendations for ongoing outpatient care.

DISCUSSION

COMPLICATIONS

Complications following the Nuss procedure occur with varying frequency, ranging from minimal to severe. One large retrospective study [8] reported that the most common complications include bar displacement, pneumothorax, wound infection, pleural effusion, and chronic pain. From other analyses:

- The overall complication rate ranges from 2 % and 27 % [9]
- In adult patients, a significantly higher risk of complications was observed, including bar displacement, bleeding, increased pain, and prolonged hospitalization [10]
- The 2004 study showed that in a group of patients (n=335), postoperative complications accounted for 16.1 %. Among early complications (within 30 days), the most frequent were pneumothorax (6.9 %), serous fluid accumulation (3.3 %), and bar displacement (2.4 %). Among late complications (beyond 30 days), pericardial effusion (1.5 %), bar displacement (1.2 %), and pleural hematoma (0.9 %) were observed [11].

BAR DISPLACEMENT AND REOPERATIONS

The percentage of bar displacement cases after the Nuss procedure is relatively low, and various data can be found in the literature. The outcome is largely determined by surgical technique, patient age, the use of stabilizers, and double bars [12].

- In a 2023 analysis, Muzammil Akhtar, Daniel Razick demonstrated that bar displacement occurred in 4.5% of patients in a group of 1135 people [6] .
- The authors also analyzed this group and reported that only 2.4% of the patients underwent reoperation.
- The literature suggests that early displacement of

the bar (within the first 3- 6 months postoperatively) may occur more frequently, primarily among patients who did not follow guidance to limit strenuous physical activity or avoid injury. At a later stage, the risk of displacement significantly decreases.

BAR FRACTURE

Bar fracture after Nuss surgery is a relatively rare but very serious mechanical complication requiring reoperation

- In a 2006 analysis, Andre Hebra, M.D., and Jeffrey P. Jacobs reported that, in a group of patients (n=30), fracture of the bar stabilizer accounted for 3% of all complications [13]
- The situation is so rare that in later publications, the complication is not listed as a separate item
- One of the most dangerous consequences of a bar fracture is injury to major vessels such as the intercostal arteries, the internal thoracic artery

SHOCK

Shock after Nuss surgery is a very infrequent but very serious complication. It is most often related to the perioperative or early postoperative period. Depending on the cause, the following types can be distinguished:

- Hemorrhagic – due to bleeding from cardiac or vascular injury
- Septic – due to postoperative infection
- Anaphylactic – due to an allergic reaction to a medical device – bar

Based on available studies and meta-analyses, it can be concluded that shock after the Nuss procedure occurs extremely rarely and is not a typical complication of this surgery.

- In the meta-analysis by Kanagaratnam A. (2016) covering (n=1432) patients, including 912 who underwent the Nuss procedure, shock was not listed as a major complication [14].
- In other meta-analysis by Hamza Rshaidat, Eliyahu Gorgov (2024) covering (n=2843) reported that, postoperative hemorrhagic complications occurred at very rarely [15]
  - 0.86% in pediatric patients
  - 3% in adult patients

In this same study, female patients had higher hemorrhagic complications (≈6%) than males (≈0.97%)

- In next analysis Turkan Dubus (2024) compared complications between pediatric (n=53) and adult (n=37) groups. She noticed only one hemothorax in each group in postoperative early complications and neither in postoperative late complications [16].

However, isolated cases of shock as a late complication of the Nuss procedure requiring surgical intervention have been reported.

- A teenager was admitted to the hospital two months after the Nuss procedure with symptoms of shock and cardiac tamponade due to damage to the ascending aorta caused by a displaced rod [17].
- Chieh-Wen Lin, Ke-Chi Chen (2011) found history of 13-year-old boy who developed late-onset bilateral hemothorax with hypovolemic shock 5 months after the Nuss procedure. They stressed that, this is the first case of the late-onset life-threatening bilateral hemothorax with hypovolemic shock ever reported [18].

MORTALITY

The Nuss procedure is widely considered a safe and effective surgical "gold standard" for correcting pectus excavatum. The overall incidence of minor and major complications that have been reported ranges from a low of 2% to a high of 27%. The Clavien-Dindo severity grading system classifies complications into 5 grades with grade 4 being life-threatening complications and grade 5 being death of the patient. Most of the complications associated with the Nuss repair are fortunately grade 1-3 and either cause minimal to no harm to the patient, or with grade 3 complications require some surgical or radiographic intervention. For grade 4 and 5 complications with the Nuss repair , the true incidence is not well-established and there is only estimated mortality risk <0.1% overall (very rare) [19].

CONCLUSIONS

Although low-energy injuries usually do not cause significant health damage, the overall clinical impression, the ABCDE assessment, and a detailed patient history are crucial. Information about previous surgical procedures can be invaluable in identifying the source of an acute health threat. With access to Evidence Base Medicine EBM), the analysis should consider all possible causes - from the most common, through the rarest, to those not described in the medical literature but potentially possible. In hospital care, especially at the E.D. level, continuous reassessment of the patient's general condition and the use of bedside methods—such as POCUS ultrasound—facilitate early recognition of shock, determination of etiology, monitoring of dynamics, and evaluation of response to treatment. Early and appropriate anti-shock management increases the likelihood of perioperative survival, which is essential for definitively controlling the source of bleeding, particularly in situations that exceed the routine capabilities of a given hospital and require long-distance transport.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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