



Traumatic pancreas, kidney, liver, spleen, gastric and diaphragma rupture with enterothorax after blunt trauma caused by falling in an adolescent: a case report

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Abstract

Injury of almost all intra-abdominal organs in blunt trauma without bone and brain injury is very rare. This is the case report of a 16-year-old adolescent with severe abdominal trauma who was hit on his abdomen by a falling maytree. After admission to a Level I trauma center, emergency room treatment according to ATLS and after this emergency surgery was performed. Blood coagulation diagnostics was done using thrombo-elastography and factors and blood products have been applied according to its results keeping guidelines in mind. Damage-control surgery stopped the bleeding, and he was admitted to ICU. After second and third look surgery, the abdomen was closed. Structured diagnostics and treatment were crucial in this case. The education of trauma surgeons should include general surgery skills. These skills and knowledge of blood coagulation diagnostics and therapy saved the patient's life in this case.

Keywords Abdominal trauma · Maytree · Liver trauma · Pancreatic trauma · Enterothorax

Introduction

Severe blunt abdominal trauma, including rupture of the diaphragm, liver, spleen, stomach, bowel, kidney, and pancreas without a brain or skeletal injury in adolescents, is very rare and was not published yet. Treatment of this combination of solid abdominal organ injuries is challenging for the emergency physician in a pre-hospital setting who stabilizes the patient—or does further harm—and which facility is suitable to treat the suspected injuries. In certified *DGU® Traumanetzwerk* regions in Germany, Switzerland, and Austria, a certification process according to the German Trauma Society *DGU®*, level I trauma centers are defined for treating the severely injured. It is mandatory to provide

immediate complete emergency trauma treatment by trauma surgeons, anesthesiologists, and intensive care physicians in these centers.

This outlines the importance of a well-trained trauma surgeon in abdominal surgery. According to modern educational concepts, surgeons are more likely to be trained in orthopedics than in abdominal surgery due to a decrease in severe trauma. In German-speaking countries, only military surgeons have mandatory training in all abdominal, orthopedic, vascular, thoracic, and neuro-surgery for a minimum of 9 years (mostly more), including a minimum of one board certification as a general or visceral surgeon before their first deployment as a responsible surgeon.

Case report

On May 1, 2021, a 16-year-old adolescent with a height of 165 cm and a body weight of 48.5 kg (BMI 18) was involved in traditionally erecting a maytree in Salzburg, Austria. Usually, this ceremony includes many people, traditional food, wine, and beer. Due to COVID-19-restrictions, only a few men, including the 16-year-old, were in charge of erecting the maypole. Suddenly, the maytree became unstable and fell, and the 16-year-old tried to catch the 20 m maytree

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(Fig. 1). He was severely hit in the abdominal region. The emergency physician was called and arrived by emergency helicopter 14 min after the accident. The patient seemed stable with RR 140/90, HR 110, regular breathing frequency but decreased sound on the left chest, and SpO₂ within normal limits. An emergency ultrasound examination did not show free intraabdominal fluid or a clear pneumothorax on the left side, so no thoracic drain was inserted. After examination and stabilization of the patient on-site for 20 min with two iv-lines and 1000 ml crystalloid fluids, the patient was flown to the nearest level I trauma center, which was a flight time of about 8 min.

The patient was admitted to the level I trauma center emergency trauma room (ER) at 4:12 pm, where the trauma team was awaiting him. The guidelines-oriented ER assessment included clinical examination according to ATLS with eFAST. A spleen lesion was suspected, and a pneumothorax on the left side could be seen. Table 1 presents emergency blood cell count with Hemoglobin (Hb) of 16 g/dl (4:14 pm) and 16.1 g/dl (4:29 pm). Now, the patient showed signs of initial shock with RR 100/57 mmHg and HR 145/min, and a CT scan was performed (Figs. 2 and 3). On the CT scan, the following diagnoses could be found: entero-thorax with

diaphragm rupture left side, gastric rupture, spleen rupture, intra-capsular liver rupture, complete pancreatic tail rupture, suspected left kidney rupture with ureter avulsion. No fractures or brain injuries could be identified. Indication for emergency surgery was set, and the patient was admitted to the emergency room 31 min after admission to our trauma center. At this time, he had a breathing rate of 30/min. For blood coagulation diagnostics, elastic motion thrombelastography TEG (ClotPro[®], enicor GmbH, Munich, Germany) was performed and did not show coagulopathy (Figs. 4, 5, 6, 7, 8, 9). The patient received 1 g of tranexamic acid and another 1000 ml crystalloid fluid in the emergency room, 600 IE human prothrombin complex (human coagulation factors II, VII, IX, and X) and 8 g fibrinogen intraoperatively, low-dose catecholamines, and no blood units but another 1000 ml crystalloid fluid in the first hour after admission.

Emergency damage-control surgery was performed between 4:51 and 8:34 pm; Hb was 11.8 g/dl (4:55 pm), 10.4 g/dl (5:20 pm), and 12.7 g/dl (6:36 pm), respectively. The complete left diaphragm rupture was found, stomach, spleen, and parts of the small bowel were dislocated in the left hemithorax with pneumothorax. First, the organs were

Fig. 1 Fallen 20 m maytree



Table 1 Laboratory results from admission until end of surgery

	4:18 pm		5:20 pm		5:44 pm		7:40 pm	
Hb g/dl	16.0	2 g FC	11.8	4 g FC	12.7	600 PCC	12.7	2 g FC
Hct %	45.7	1 g TXA	34.0		36.0	4 PRBCs	35.8	
Platelet count/ μ g	281		206				139	
PTI %	84							
aPTT sec	26.3							
Fibrinogen mg/dl	225				238			
Lactate mmol/l	3.0							
BE mmol/l	-5.5							
IL-6 pg/ml	25.4							

FC fibrinogen concentrate, TXA tranexamic acid, PCC prothrombin complex concentrate, PRBC packed red blood cells



Fig. 2 Frontal view CT scan of thorax and abdomen with enterothorax, liver, kidney and spleen ruptures



Fig. 3 Axial view of abdominal CT scan with liver, pancreas, kidney, and spleen rupture

relocated into the abdomen, and the bleeding spleen was resected. Second, the liver was inspected where multiple hematomas but no capsule rupture could be found. Then, the bowel was mobilized and inspected: the gastric cardia rupture was identified next to several minor bowel serosa

injuries. The long and curved appendix was found in a retrocecal position. The colon was intact. The complete pancreas tail rupture could be seen after approaching the omental bursa and mobilizing the duodenum. The retroperitoneal layer showed massive hematoma: it was opened and the left kidney was evaluated: there was a small rupture without ureter or vessel avulsion. The hematoma was evacuated and the fascia was closed.

A mixture of undigested sausages and bread was manually removed from the whole left hemithorax, including irrigation with a catheter in the mediastinal region next to the heart. VIDEO The cardia rupture was sutured manually. Then, as the pancreatic duct could not be found, a direct suture of the pancreatic tail was placed, and a round drain was positioned next to the sutured injury. The serosa injuries of the small bowel were sutured. After this, a thoracic drain was placed on the left side and the diaphragm was re-inserted with sutures. Lavage of the abdomen with many liters of warm fluid and removal of all remaining sausages followed. Abdominal vacuum-assisted closure was placed and the patient was transferred to ICU after 3.5 h operating time with a body temperature of 36.5 °C, RR sys 140, and HF 100 (Fig. 10). The patient received four blood units and 7.5 l of crystalloid infusions during surgery. At ICU, he received 1500 ml colloidal fluids and 100 ml/hour as permanent infusion and 0.34 µg/kg/min noradrenaline. Overall, 10 l infusions were applied from admission until end of surgery, normal urinary clearance was seen. Lactate showed a range between 2.6 and 4.3 mmol/l. Table 1 shows hemoglobin and coagulation before and during surgery. Hb was 12.6 g/dl at 9:38 pm.

After 36 h, a second look was performed: Appendectomy was performed because of the retrocecal position with a stapler. Lavage and another vacuum-assisted closure were applied. Two more blood units were given. Hb remained stable between 10.6 (May 2 1:53am) and 13.9 (May 3 6:03 pm).

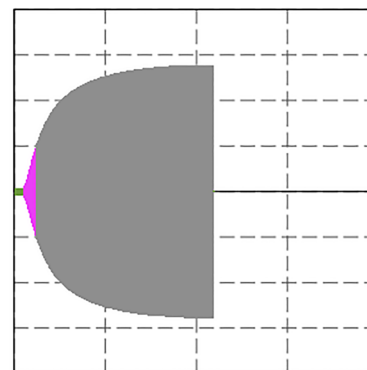
After two days, a third look showed initial digestion of the pancreatic tail around the suture, and a pancreatic tail resection and lavage of the abdomen was performed. The abdomen was closed and four drains were inserted: one next to the tail of the pancreas, one in the liver region, one in the former splenic area, and one in the Douglas space. 1000 IE Antithrombin III and 1200 IE human prothrombin complex were applied. Hb was 9.9 (May 6 1:56 pm).

The patient remained stable but still showed pneumothorax on the left side. Tracheostomy was performed 13 days after admission and the thoracic drain left side was re-inserted, which led to much better ventilation parameters and less need of sedation.

After seven days, the young and small patient developed a hard abdominal wall without signs of an acute abdomen: he showed some hematemesis via stomach tube and esophagogastroduodenoscopy was performed. This revealed one

Proben Nr. oder QC: Lot ID171077
 Patienten Nr. : 9655/1
 Test : EX-test
 Startzeit : 01.05.2021 16:25:59 - Laufzeit: 22m:05s (Messung läuft)
 Ergebnisse :

CT	71s	▲ 38-65
A5	44mm	▶ 39-58
A10	52mm	▶ 47-64
A20	55mm	▶ 52-67
MCF	56mm	▶ 53-68

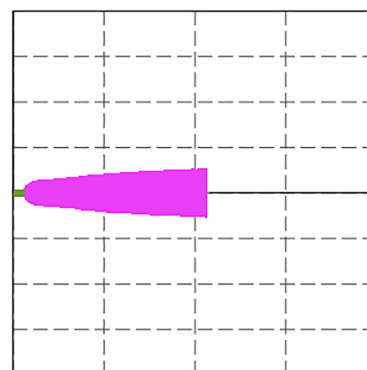


Kanal: 2
 t: EX44172AA c:

Figs. 4–9 Elastic motion thrombelastography TEG (ClotPro®, enicor GmbH, Munich, Germany) from admission in ER to end of surgery

Proben Nr. oder QC: Lot ID171077
 Patienten Nr. : 9655/1
 Test : FIB-test
 Startzeit : 01.05.2021 16:26:27 - Laufzeit: 21m:37s (Messung läuft)
 Ergebnisse :

CT	73s	▶ 55-87
A5	7mm	▶ 6-21
A10	9mm	▶ 7-23
A20	11mm	▶ 8-25
MCF	11mm	▶ 9-27



Kanal: 3
 t: FI44144AA c:

Figs. 4–9 (continued)

gastric ulcer, which was treated conservatively with high-dose proton-pump inhibitors (PPI) that he received in normal doses already. Another two blood units were given. The gastrointestinal passage was pervasive after nine days without any problems. Four days after the third look surgery, all drains except the pancreatic drain were removed—the remaining drain was removed on day 24 after almost no liquid left, and amylase/lipase was almost within normal limits.

Overall, he showed a balance of +20.5 l (infusion: 57 l) after the first week and a balance of −33.5 l after the second week. Twenty-three days after surgery, he reached normal body weight again.

On day 20, he was fully awake, and tracheostomy could be left open with speech and language therapy on day 30. The transfer from ICU to the ward was done on day 24. He was stable and satisfied.

Suggested vaccinations were received five weeks after trauma and splenectomy.

After 37 days, the patient was discharged home without any restrictions, having pizza and soft drinks every day. Today, he is fully re-integrated into his old life without significant problems—a long abdominal scar reminds him of May 1, 2021.

Discussion

Trauma emergency field treatment may include pre-hospital emergency fast sonography for trauma (eFAST) with small and transportable ultrasound devices. The advantages of using on-field eFAST-devices are discrimination of free intraabdominal fluid and pneumothorax for next-step decision-making as insertion of thoracic drain and primary

Proben Nr. oder QC: Lot ID1710776743

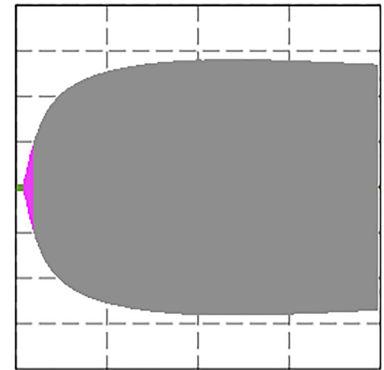
Patienten Nr. : 9655/21

Test : EX-test

Startzeit : 01.05.2021 17:20:31 - Laufzeit: 40m:00s (Gestoppt)

Ergebnisse :	CT	62s	▶ 38-65
	A5	44mm	▶ 39-58
	A10	52mm	▶ 47-64
	A20	56mm	▶ 52-67
	MCF	56mm	▶ 53-68
	ML	4%	▶ 2-12

Kommentar : OP nach 4g FIB



Kanal: 1
t: EX44172AA c:

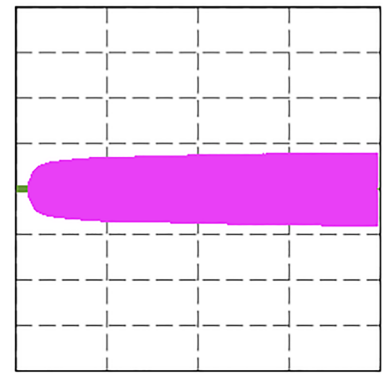
Proben Nr. oder QC: Lot ID1710776743

Patienten Nr. : 9655/21

Test : FIB-test

Startzeit : 01.05.2021 17:20:58 - Laufzeit: 40m:00s (Gestoppt)

Ergebnisse :	CT	77s	▶ 55-87
	A5	13mm	▶ 6-21
	A10	14mm	▶ 7-23
	A20	15mm	▶ 8-25
	MCF	16mm	▶ 9-27



Kanal: 2
t: FI44144AA c:

Figs. 4–9 (continued)

Proben Nr. oder QC: Lot ID1710776743

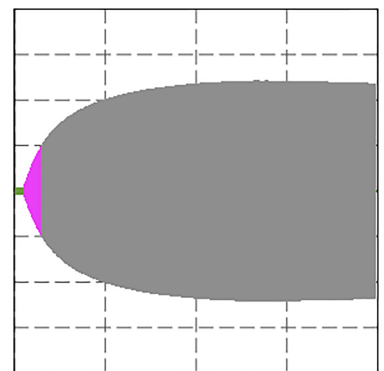
Patienten Nr. : 9655/21

Test : EX-test

Startzeit : 01.05.2021 19:24:46 - Laufzeit: 40m:00s (Gestoppt)

Ergebnisse :	CT	71s	▲ 38-65
	A5	33mm	▼ 39-58
	A10	42mm	▼ 47-64
	A20	48mm	▼ 52-67
	MCF	49mm	▼ 53-68
	ML	3%	▶ 2-12

Kommentar : nach 600 PCC



Kanal: 3
t: c:



Figs. 4–9 (continued)

Proben Nr. oder QC: Lot ID1710776743

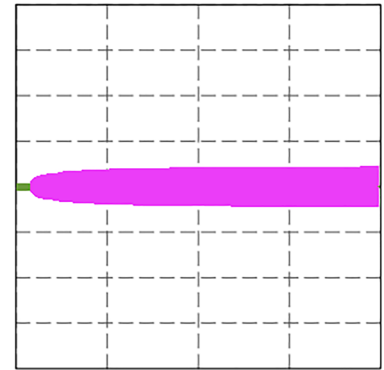
Patienten Nr. : 9655/21

Test : FIB-test

Startzeit : 01.05.2021 19:25:30 - Laufzeit: 40m:00s (Gestoppt)

Ergebnisse :	CT	94s	▲ 55-87
	A5	7mm	▶ 6-21
	A10	8mm	▶ 7-23
	A20	8mm	▶ 8-25
	MCF	9mm	▼ 9-27

Kommentar : nach 600 PCC



Kanal: 4

t: c:



Figs. 4–9 (continued)

Proben Nr. oder QC: Lot ID1710776743

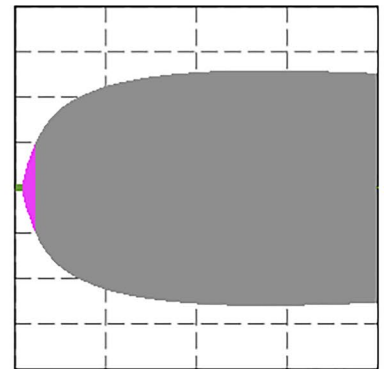
Patienten Nr. : 9655/21

Test : EX-test

Startzeit : 01.05.2021 19:48:03 - Laufzeit: 40m:00s (Gestoppt)

Ergebnisse :	CT	59s	▶ 38-65
	A5	38mm	▼ 39-58
	A10	46mm	▼ 47-64
	A20	51mm	▼ 52-67
	MCF	52mm	▼ 53-68
	ML	3%	▶ 2-12

Kommentar : nach 600 PCC FC 2g



Kanal: 5

t: c:



Proben Nr. oder QC: Lot ID1710776743

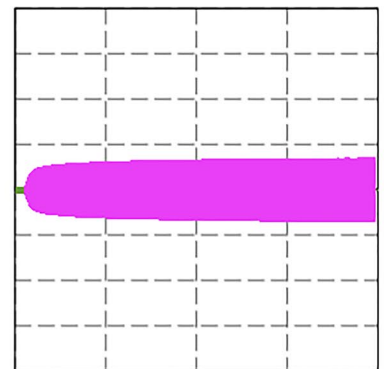
Patienten Nr. : 9655/21

Test : FIB-test

Startzeit : 01.05.2021 19:48:53 - Laufzeit: 40m:00s (Gestoppt)

Ergebnisse :	CT	64s	▶ 55-87
	A5	12mm	▶ 6-21
	A10	13mm	▶ 7-23
	A20	14mm	▶ 8-25
	MCF	14mm	▶ 9-27

Kommentar : nach 600 PCC FC 2g



Kanal: 6

t: c:



Figs. 4–9 (continued)

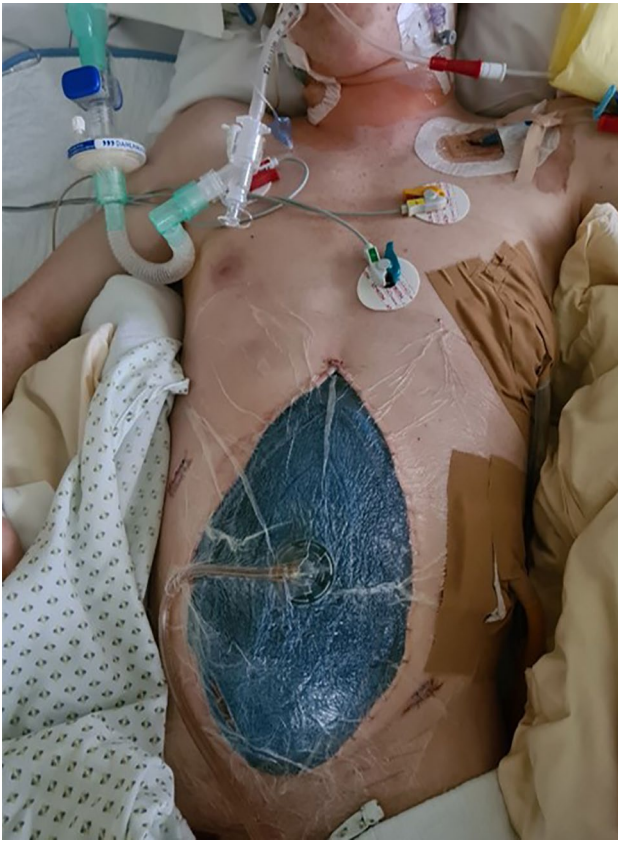


Fig. 10 Abdominal vacuum-assisted closure after first surgery

transport in a level I trauma center for assessing abdominal injuries. Even though this was performed in this case, no clear evidence of pneumothorax or free intraabdominal fluid could be seen—the disadvantage of these devices may be an interpretation of findings according to the investigator's experience in a field setting with challenging weather conditions, bright light, or darkness and raised stress-level—thus, the risk of false-negative findings exists. With increased heart rate and decreased breathing sound, insertion of a thoracic drain would have been indicated. However, normal SpO₂ and short flight time to hospital contradicted this procedure for the emergency physician in this situation [1–3].

Guidelines-oriented Emergency Trauma Room Assessment according to the ATLS algorithm is mandatory for standardized trauma room treatment [4]. Essential adjuncts to clinical assessment are eFAST, CT, and blood analysis focusing on coagulation. The trauma team always includes one general/abdominal board-certified trauma surgeon who is able to perform all life-saving trauma emergency procedures. This may change in future, as orthopedic surgeons receive no training in abdominal surgery and real trauma surgeons are becoming a very rare entity in Europe.

Keeping the patient warm, fluid management, and optimizing coagulation are the most important factors for a

trauma patient's survival. Blood coagulation management in trauma patients is challenging but crucial. In our hospital, we treat according to the most recent literature and scientific findings [5–7]. Elastic motion thrombelastography TEG helps to take correct countermeasures in coagulation management, as seen in this case. TEG did not show clear signs of coagulopathy, which may indicate relatively stable patient conditions without any acute life-threatening bleeding. With a reduced need for blood units but an expectable need for some coagulation factors, hemostasis management could be achieved according to current guidelines [7].

The surgical strategy was straightforward to stop the bleeding: in this case, splenectomy was the first important goal to achieve [8]. Second, the remaining food debris was removed from the left hemithorax and the ruptured stomach and diaphragm were sutured. Third, the pancreatic rupture was assessed, and drains were inserted before the abdominal vacuum-assisted closure was applied as second or third look surgery was already scheduled, and abdominal compartment syndrome is a dangerous complication after abdominal trauma [9]. As damage-control surgery should be fast and live-saving, the number of injuries combined with much intrathoracic debris made a longer operating time necessary. Fluid management was quite aggressive as the patient seemed to profit intraoperatively [10–12]. The patient showed clinical signs of shock. However, looking at TEG and the patient's need for blood transfusions, the state of definitive shock remains questionable [13].

Multiple stage surgery in severe abdominal trauma is recommended. No anastomosis or abdomen closure should be performed in damage-control surgery, and abdominal vacuum-assisted closure is first-line therapy [14, 15]. Pancreatic tail resection is the best option if no pancreatic duct can be found and pancreatic juice starts to digest the bowel [16]. After resection, a drain is mandatory to survey possible suture insufficiency. If possible, the abdomen should be closed as soon as possible to avoid the organ's loss of domain. In the absence of any signs of infection, no anti-infective therapy was applied during admission, which was the right decision although antibiotic single/double-shot prophylaxis was administered prior and during surgeries. Antibiotic or antimycotic therapy should only be used in the case of clear evidence of infection as the use of antibiotics may not be evidence-based and may further harm the intestinal flora. In this case, the patient developed no thoracic empyema in this high-risk situation. The development of post-traumatic gastric ulcers is not rare and should be kept in mind in every severe abdominal trauma patient. Besides prophylactic treatment with PPI, the patient's stress levels should be as low as possible using special nursing techniques and anesthesia. Fluid management is still being discussed but worked out as it saved the number of blood cell units given, in this case [17]. Even experienced board-certified

trauma surgeons do not see these injuries often in central Europe. However, there is no alternative to permanent skill training to be prepared to treat severely injured patients like this young man. This may only be provided through damage-control surgery courses, military surgery courses, fellowships in South Africa or South America, or military deployments of surgeons to hot spots, as in this case to Afghanistan or Iraq. Current resident programs in orthopedics do not train these skills for general surgeons or orthopedic trauma surgeons. As general surgeons train for minimally invasive laparoscopic surgery and open trauma surgery remains rare in Europe, abdominal, thoracic, and vascular surgery skills are mandatory in level I trauma centers—with specialists in subspecialties or “old-fashioned” trauma surgeons with both orthopedics and abdominal surgery board certification.

Immediate structured coagulation and fluid management were crucial and led to stable intra- and post-operative measures at any time during emergency treatment.

In this unique case, ATLS Guidelines-oriented treatment led to immediate surgical intervention, which was life-saving because general surgical expertise was immediately available.

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Author contribution All authors contributed to the study conception and design. AJS and GF performed material preparation, data collection, and analysis. AJS wrote the first draft of the manuscript and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. Conceptualization: AJS. Methodology: AJS and GF. Formal analysis and investigation: AJS and GF. Writing—original draft preparation: AJS. Writing—review and editing: AJS and GFR. AJS. Supervision: AJS.

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Availability of data and material With corresponding author due to ethical committee vote.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to this article’s content. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

Ethical approval The study was approved by the institutional ethical committee and the authors certify that the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent to participate With authors.

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