Traumatic abdominal wall hernia as a component of the seatbelt syndrome: Complete abdominal wall muscles transection treated with two-stage surgery and retrospective review in a first-level hospital.

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Short Report

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Abstract

Background

Seat belt syndrome (SBS) is a rare condition described as injuries sustained due to thoracic, abdominal, and pelvic compression in the context of traffic accidents. These injuries can range from minor skin abrasions to large lesions of internal organs and spinal cord involvement. Traumatic abdominal wall hernias (TAWH) are one of the injuries that can be associated with this condition.

Material and Methods

We present a review of our case series and the description of a unique case of a 21-year-old male with a high severity injury, with complete transection of all abdominal wall musculature secondary to SBS, with associated visceral injury. Emergency surgery required intestinal and sigmoid colon resection, as well as repair of the cava vein. After a long recovery period, a second-stage surgery was planned for abdominal wall reconstruction, with prehabilitation using botulinum toxin and pneumoperitoneum, as well as surgical planning with a CT scan with 3D reconstruction of the abdominal wall defect.

Results

A retrospective review was conducted of patients with SBS, of whom only 6 presented with TAWH. Five out of the 6 cases had associated intrabdominal visceral injuries, with emergency surgical treatment required. In the case of complete transection of the abdominal wall, a second surgery was required for scheduled abdominal wall reconstruction, involving transversus abdominis release and placement of double mesh.

Discussion

The therapeutic approach to traumatic abdominal wall injuries should be individualized to each patient, with a focus on addressing vital injuries first and considering abdominal wall reconstruction surgery at a subsequent stage. Utilizing CT scan with 3D reconstruction can serve as a valuable tool for preoperative planning in cases involving significant abdominal wall defects.

BACKGROUND

High-speed traffic accidents are a frequent cause of abdominal wall injuries and can also result in visceral injuries. The use of a seat belt can be involved in the injury mechanism in what is known as the seat belt syndrome (SBS).

Avulsion is a specific and rare type of injury in traffic accidents that involves the separation of tissues, such as muscle or bone. In the case of abdominal wall avulsion, there is an injury to the muscle that is usually accompanied by injuries to the hollow viscera or splenic lacerations, which usually requires emergency surgery [1-9]

The indication for emergency or deferred surgery depends on several factors, including the severity of the injuries, the patient's condition, and the available resources.

Immediate surgery may be appropriate in cases of severe injuries that threaten the patient's life, such as massive abdominal hernias or internal organ injuries, that can cause rapid blood loss or multi-organ failure and must be treated immediately to avoid serious complications or the patient's death. [10-13]

On the other hand, deferred surgery may be appropriate in cases of less severe injuries or in patients with other severe injuries that require priority attention. This allows the patient to stabilize before surgery and allows the surgical team to plan surgery more effectively and under the best conditions. However, deferred surgery must be performed within a prudent timeframe to avoid complications.

In general, the decision on when to perform surgery should be made by a medical team specialized in abdominal wall surgery and should be based on an individualized assessment of each patient and their clinical condition.

The evidence on reconstructive abdominal wall surgery after abdominal avulsion or traumatic hernias caused by SBS is limited. However, there are some published studies and clinical cases that suggest good results in both immediate and deferred surgery.

In some cases, reconstructive surgery has been used to repair damaged abdominal wall and muscles by suturing the muscles and placing mesh to strengthen the abdominal wall. In more severe cases, reconstructive surgery to repair pelvic bone injuries has been performed by fixing the bone fragments or rebuilding using bone grafts.

Regarding surgical planning, the use of 3D images in abdominal wall surgery has been studied in recent years. 3D computed tomography (CT) has been proposed as a useful tool for surgical planning and evaluation of patients with abdominal wall pathology. However, the current evidence on its application in abdominal wall surgery is limited.

Although it is a developing area of research, recent studies have shown that the use of 3D CT in the surgical planning of patients with incisional hernias has allowed for a better understanding of anatomy and increased accuracy in hernia localization [14-18]

In addition, a reduction in the rate of postoperative complications in patients undergoing inguinal hernia surgery planned with 3D CT has been observed compared to those planned with 2D images [19]

Despite the benefits it can provide, the use of this type of imagery may incur additional costs that need to be considered in a public healthcare system. However, these costs may be justified when considering that the precision and effectiveness of surgery improve through 3D planning, which, in turn, can reduce surgical time and the need for additional procedures, thereby reducing long-term costs.

Given the limited evidence, we present a case of extreme severity involving complete transection of the abdominal wall due to traumatic causes. The reconstruction was performed in two stages, utilizing 3D imaging for optimization of surgical planning. Additionally, we performed a retrospective review of cases within our institution involving patients diagnosed with traumatic injury or herniation within the context of seat belt syndrome.

MATERIAL AND METHODS

We present the case of a 21-year-old male who was transported to the emergency room after a front-end collision with a motor vehicle. The accident occurred at 80km/h with the seat belt properly positioned in two parts, shoulder, and abdomen.

Upon arrival at the emergency room, the patient was evaluated according to the guidelines for the management of the polytraumatized patient with a systematic approach based on the priorities indicated by the Advanced Trauma Life Support (ATLS).

Following the primary assessment, with no alterations in A, B, C, or D, an examination of external injuries is performed, revealing cutaneous erosion on the thoracic and abdominal regions following the pattern of a seatbelt. As part of the complementary tests, a full-body CT scan is carried out, showing complete transection of both rectus abdominal muscles and the lateral musculature of the abdominal wall (both oblique muscles and transverse muscle) with avulsion of the iliac spine. Additionally, intra-abdominal injuries such as hematoma of the vena cava, intestinal, and sigmoid colon injuries are observed (figure 1).

Given the findings, urgent surgery is decided upon. A wide supra-umbilical midline laparotomy is performed for intestinal and vascular reparative surgery, along with provisional abdominal closure, muscle approximation, and cutaneous closure without repairing the abdominal wall due to hemodynamic instability.

During the postoperative period, the patient experiences respiratory distress secondary to the acute process and respiratory superinfection, with difficulty in extubating exacerbated by muscle weakness acquired during a prolonged stay in the intensive care unit and respiratory desynchrony due to the complete section of the abdominal wall musculature, requiring assistance for voluntary breathing.

After the acute process and complete physical recovery, the planning for reconstructive surgery of the abdominal wall is initiated. The preoperative CT scan reveals an extensive defect in the abdominal wall with a complete section of the right lateral musculature, complete section of both rectus abdominal muscles, and partial section of the left abdominal musculature. The right lateral musculature is largely absent, leading to a global defect measuring 12cm cranio-caudally and 25cm in maximum transverse diameter (figure 2).

Due to its extent, reconstruction with a myocutaneous flap is ruled out, considering the absence of a vascular point in the abdominal wall (complete section of the inferior epigastric vessels in the angio-CT) and the patient's characteristics. Therefore, a decision is made to perform an anatomical abdominal surgery, utilizing posterior component separation and surgical prehabilitation. Botulinum toxin is applied at 3 points in the remaining right lateral musculature and 5 points on the left six weeks before surgery, achieving a minimal reduction of the defect and progressive pneumoperitoneum creation 15 days prior to surgery (figure 3).

For surgical planning, a 3D reconstruction of the abdominal musculature was performed using image creation by CELLA Solutions, aimed at assessing the remaining tissue to select and optimize the surgical technique (figure 4 and electronic supplementary material).

Surgical procedure

In the case of the musculature in the left hemiabdomen, there is evidence of a partial injury to the internal and external oblique muscles, with a complete section of the left rectus muscle. Despite the section, the anterior and posterior fascia appear intact, so a complete anatomical repair was performed with suturing of both fascia and muscle approximation.

In the case of the right hemiabdomen, there was a complete section of both oblique muscles, the transversus abdominis muscle, as well as the right rectus abdominal muscle, with significant muscle separation and absence of tissue to allow for a complete approximation ensuring anatomical repair. Therefore, a bilateral posterior component separation with the existing tissue was decided, requiring the placement of a mesh bridge for the reconstruction of the right lateral wall with a biological mesh of 30 x 20cm and over this, a polypropylene mesh of 50 x 50cm (figure 5).

RESULTS

The patient required 12 hours of stay in the intensive care unit and was subsequently transferred to a regular hospitalization ward. No complications were observed during the hospital stay and he was discharged without complications after 7 days of admission. At the 30-day post-surgery evaluation, there were no complications. From a functional perspective, the patient has recovered muscle contraction in the left hemi-abdomen, but with very limited muscle contraction in the right hemi-abdomen. There is no evidence of recurrence or bulging 1 year after reconstructive surgery.

We conducted a retrospective analysis of motor vehicle accidents involving occupants who were wearing seat belts, which were managed at our first-level institution over a 5-year period. Our institution attends to approximately 600-700 polytrauma patients annually in the context of car accidents.

During this period, a total of 3050 patients were evaluated in the emergency department. Among this cohort, only 6 cases presented with avulsion of the abdominal wall as part of their injury pattern, including the case described in this article, with a rate of 0.2% or with an estimated incidence of 2 per

1000. The mean age of the patients was 40.8 years, with a distinctly younger pattern observed in males, with a ratio of 2:1. In all cases, evidence of muscular avulsion from the iliac spine was observed, with disruption at this level, either unilateral or bilateral, without cutaneous injury (figure 6).

Of the 6 patients examined, 5 required immediate surgical intervention due to associated intra-abdominal injuries. These interventions predominantly involved intestinal or colonic resections in response to traumatic lacerations or perforations. Notably, only one patient underwent concurrent abdominal wall repair during the emergency procedure (patient C), employing an anatomically guided reconstruction technique utilizing muscle tissue suturing.

Conversely, the remaining 4 patients did not undergo immediate surgical intervention targeting the abdominal wall. Only the patient described in the article underwent delayed reparative surgery (patient A). Two of the remaining three patients underwent subsequent surgeries for intestinal transit reconstruction and are presently awaiting scheduled surgical repair for abdominal wall reconstruction (patients D and F). The third patient (patient E) declined abdominal wall reparative surgery due to being asymptomatic and not desiring further interventions.

In the case of patient B, the abdominal wall injury went unnoticed and was diagnosed by ultrasound four weeks after the accident. He underwent scheduled surgery with anatomical repair and mesh placement according to the Carbonell-Tatay technique.

The characteristics of the patients are summarized in Table I.

Table I. Summary of patients with seat-belt-associated traumatic abdominal wall hernia.							
	Age (years)	Sex (M/F)	Location of TAWH	Associated injuries	Emergency surgery	Immediate abdominal wall repair	AW Delayed surgery
A*	21	M	complete transection of both rectus abdominis muscles and bilateral lateral musculature	Sigmoid colon, small bowel, and cava vein	Yes*	no	Yes*
B	52	M	Right avulsion of the lateral musculature from iliac spine	No	no	no	Open surgery with mesh
C	27	M	Left avulsion of the lateral musculature from the iliac spine	aortic dissection, retroperitoneal hematoma, hepatic laceration, sigmoid colon, small bowel, hemothorax, multiple rib fractures	Yes: small bowel resection, Hartmann procedure, hepatic packing	Yes: anatomical repair with muscular suture	No
D	28	M	Left avulsion of the lateral musculature from iliac spine	Sigmoid colon, splenic laceration, multiple limb fractures, multiple rib fractures	Yes: Hartmann procedure	no	No. Awaiting
E	59	F	Right avulsion of the lateral musculature from the iliac spine	Small bowel, psoas hematoma, aortic dissection, multiple rib fractures, kidney laceration	Yes: ileocecal resection	no	no
F	58	F	Left avulsion of the lateral musculature from iliac spine	Rectus abdominis and psoas hematoma, small bowel, retroperitoneal hematoma	Yes: small bowel resection, Hartmann procedure	No	No. Awaiting

* Patient described in the paper

Discussion

The "seat belt syndrome" is a common condition resulting from trauma caused by the force exerted by the seatbelt after a car accident, affecting both drivers and passengers. Injuries associated with the use of a seatbelt are well-known and have been documented in medical literature.

These injuries can affect various areas of the body, especially those covered by the seatbelt. In most cases, injuries are mild, manifesting only as bruises, abrasions, and hematomas on the skin, as well as rib fractures or spinal injuries.

However, in a small percentage of high-speed accidents, severe injuries can be observed, involving both intra-abdominal organs (intestine, spleen, liver) and the abdominal wall. This can range from the development of small traumatic hernias to severe avulsions of the abdominal wall.

The case discussed in the article addresses some of the key points for the comprehensive management of polytraumatized patients with traumatic abdominal wall hernias. The first point to address is the resolution of vital injuries in an initial emergent surgery, repairing the abdominal wall only in cases of stability or anatomical feasibility, leaving definitive repair for a second stage if it requires complex surgery, as in the described case.

The second point to address is the timing chosen for the reconstructive surgery in the second stage. This depends on the type of surgery performed in the first stage, whether it is contaminated surgery, the type and severity of associated injuries, the patient's hemodynamic stability, and organic function [9,13]. In the described case, the patient had a complex postoperative course with respiratory failure and a prolonged stay in the intensive care unit. Therefore, it was decided to defer the surgery until complete recovery of the baseline condition and to be able to face complex abdominal wall surgery with prehabilitation using botulinum toxin and pneumoperitoneum.

The third point to address is the preparation and prehabilitation of the patient for complex abdominal wall repair surgery. One of the benefits of performing reconstructive surgery as a second step is the ability to physically recover the patient to face complex abdominal wall surgery without being in a critical state, and to provide prehabilitation techniques. The use of botulinum toxin allowed us to increase tissue mobility and improve its elasticity, thus facilitating anatomical approximation more easily. Regarding the use of progressive pneumoperitoneum, despite not showing loss of domain, its application allowed us to reduce omental adhesions to the peritoneum, thus facilitating the dissection of surgical spaces without visceral injury. [20]

For surgical planning, although current evidence is limited, the use of 3D reconstructions in patients with complex abdominal wall pathology seems promising and appears to have a positive impact on accuracy,

efficiency, safety, and improve short-term results after surgery, as well as reducing surgical time and decreasing the need for additional procedures, which in turn can reduce overall patient costs.

Despite the costs it may bring, the use of this type of images can have additional costs that must be considered in a public health system. However, these costs can be justified if it is considered that the accuracy and efficacy of the surgery improve thanks to the 3D planning, which in turn can reduce the surgical time and the need for additional procedures, decreasing long-term costs.

Finally, the last point to address is the technique of repair, with or without mesh. This depends on the anatomical characteristics of the traumatic hernia and, in cases of hollow viscus injuries, on peritoneal contamination since the use of prostheses in these cases may increase the risk of chronic infection. An alternative to synthetic meshes in these cases is the use of biological meshes, which are reported as safe alternatives in a contaminated environment. In cases of large tissue defects, different types of flaps and grafts have been described for abdominal wall reconstruction [21]. The choice of graft or flap will depend on the extent and location of the defect, as well as the individual characteristics of the patient. The most commonly used flaps in cases of large defects are myocutaneous flaps, such as the lateral or bilateral rectus abdominis flap or the external oblique muscle flap to cover defects in the inguinal area. In cases of large defects involving the entire abdominal musculature, flaps of the lumbar square muscle, sartorius, rectus femoris, and semitendinosus muscle can be used.

Although the use of myocutaneous flaps may yield good results, adequate vascularization must be provided to prevent necrosis. Most myocutaneous flaps rely on the intrinsic circulation of the muscle and fascia, so it is not necessary to perform vascular anastomoses to the lower inguinal vessels. However, in cases of extensive defects in the abdominal wall, it may be necessary to perform an arterial or venous anastomosis to ensure good vascularization of the flap. In some cases, myocutaneous flaps can be used with a revascularization technique, such as the rectus abdominis flap with an epigastric pedicle, to improve flap irrigation or a latissimus dorsi muscle flap. [22-24]

In the case of our patient, the fact that he is an athlete and the evidence from preoperative vascular CT showing complete section of the epigastric vessels was one of the factors that led us to opt for reconstructive surgery without flaps, considering the risk of being unable to guarantee proper vascularization to a limb flap.

Conclusions

Traumatic abdominal wall hernias (TAWH) in polytraumatic patients secondary to seatbelt use are a rare entity but should be suspected in cases of traffic accidents involving automobiles. The surgical approach to these injuries should be multidisciplinary, initially addressing vital injuries, and considering abdominal wall reconstruction surgery in a second stage.

Surgical preparation and planning should be individualized based on the patient's anatomical characteristics and the defect in the abdominal wall. Assessing the defect with 3D reconstruction

technology can be a useful tool for surgical planning and studying the actual muscle defects. However, due to its current high cost, it should be reserved for complex surgical planning of patients who require an exhaustive study of the abdominal muscles and structures for complex reconstructive surgeries.

Finally, the choice of surgical technique should again be made on a personalized basis according to the patient's characteristics and priorities, as well as the anatomical possibilities based on the type and extent of the existing defect.

Statements and Declarations

Author Contributions: IGT wrote and edited the paper. All authors: RLGG, PDMD, MQE, GJB and EAF reviewed the paper and revised it critically for intellectual content. Each author has participated sufficiently in the work of reviewing and approving the study. All authors also contributed to the surgical and clinical management of the patient.

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Informed Consent Statement: Obtained informed consent from the patient for the publication of relevant clinical information related to his case, while preserving the confidentiality of data that could identify him as the subject of the clinical case.

Ethical Approval: As only routine treatment of the patients was documented, no ethical approval was necessary.

Data Availability Statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments: Not pertinent

Conflicts of Interest: The company Cella Medical Solutions provided the 3D reconstruction images as part of the service contract with the Hospital. All authors have no conflicts of interest or financial disclosures.

Additional information: This study has not been previously published elsewhere for publication and it will not be sent to another journal until a decision will be made concerning publication by Langenbeck's archives of surgery.

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Supplementary material

Electronic supplementary material is not available with this version

Figures

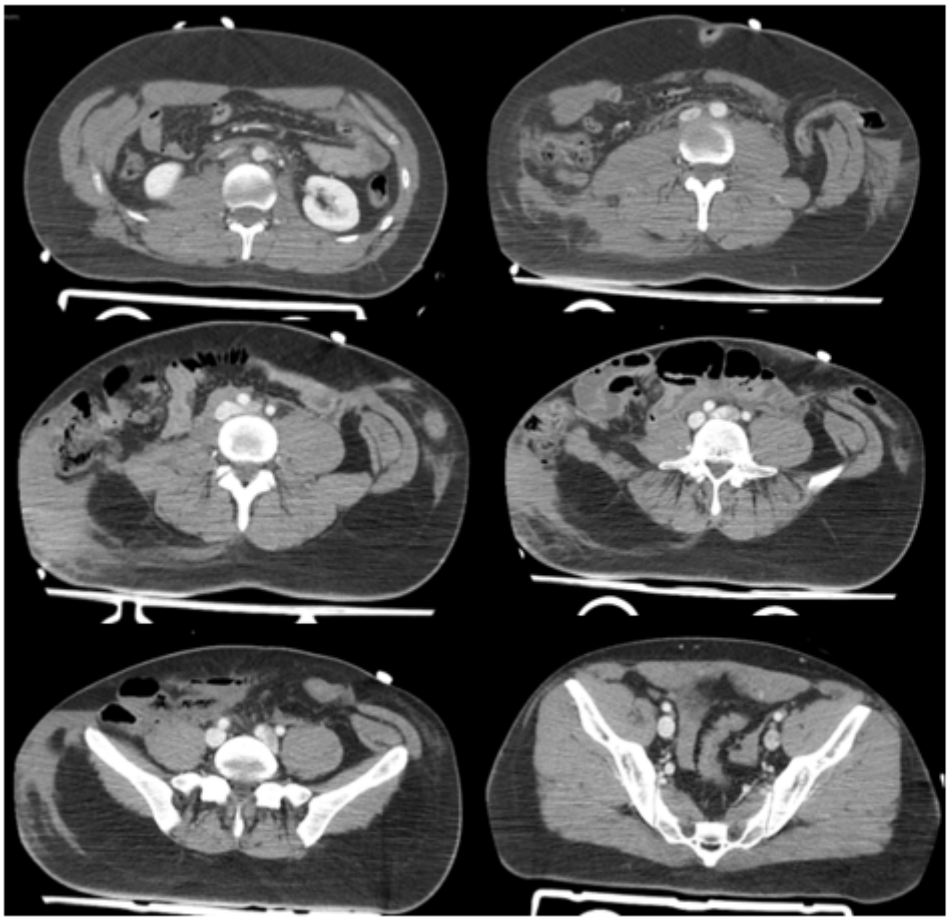

Figure 1

Emergency abdominal CT scan performed before urgent surgery.

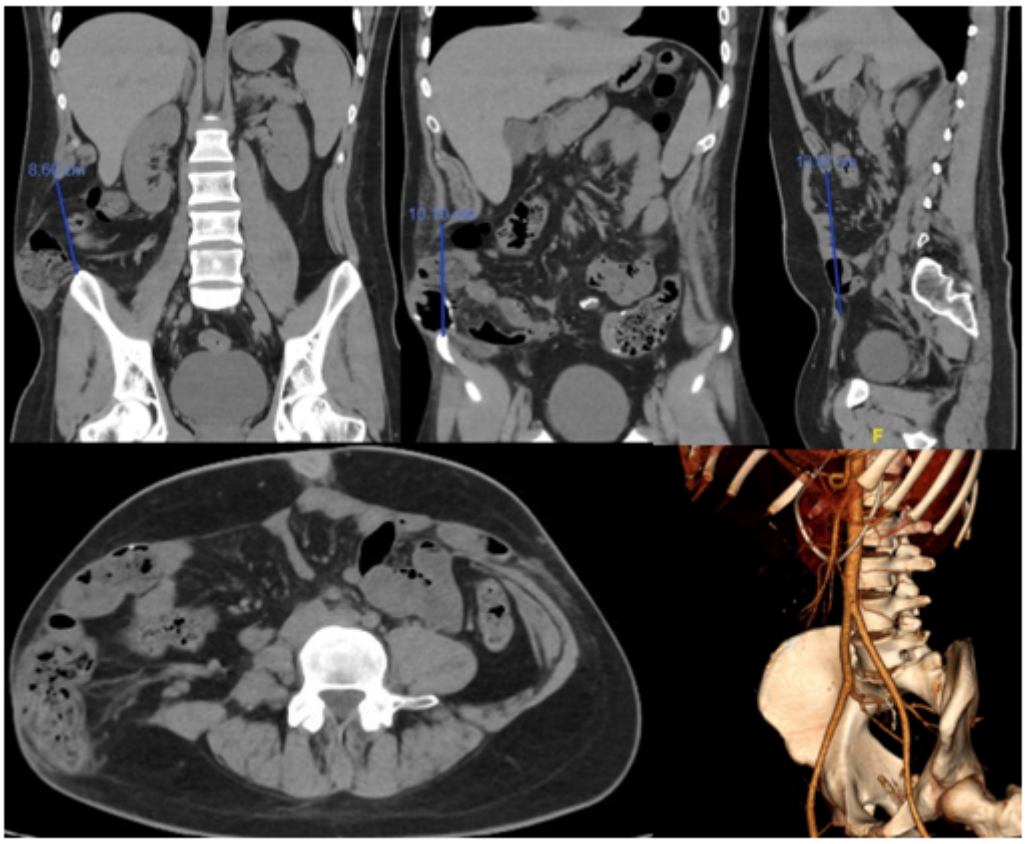

Figure 2

Abdominal CT scan before the administration of botulinum toxin. Vascular reconstruction.

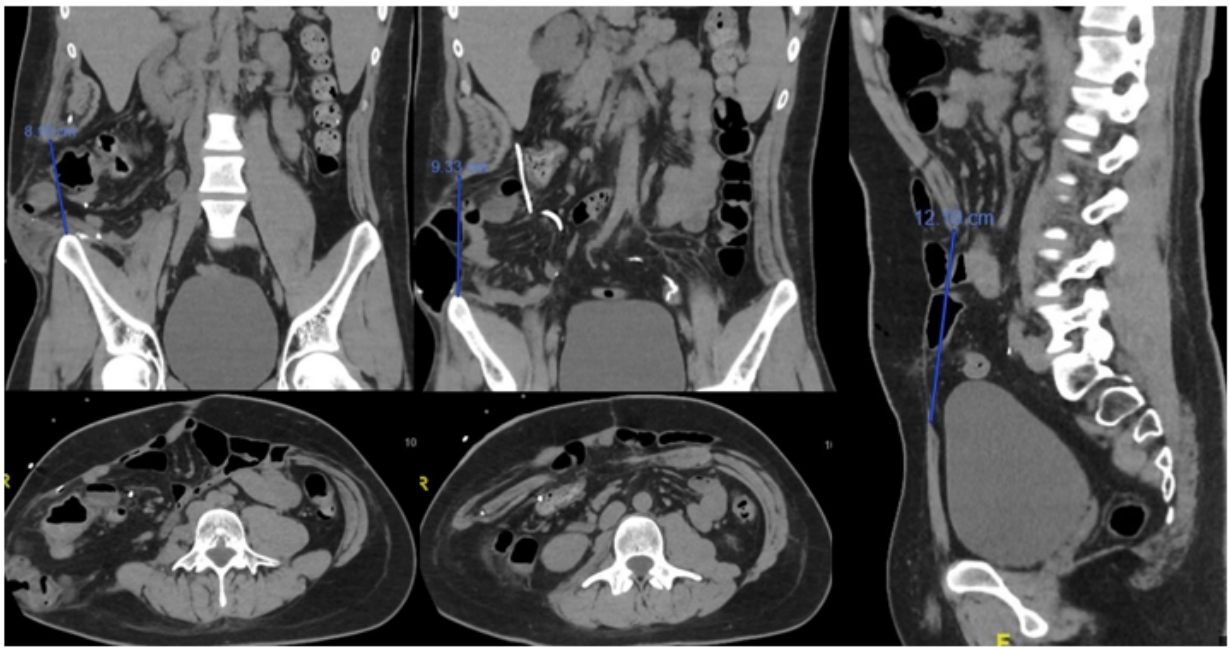

Figure 3

Abdominal CT scan six weeks after the administration of botulinum toxin,

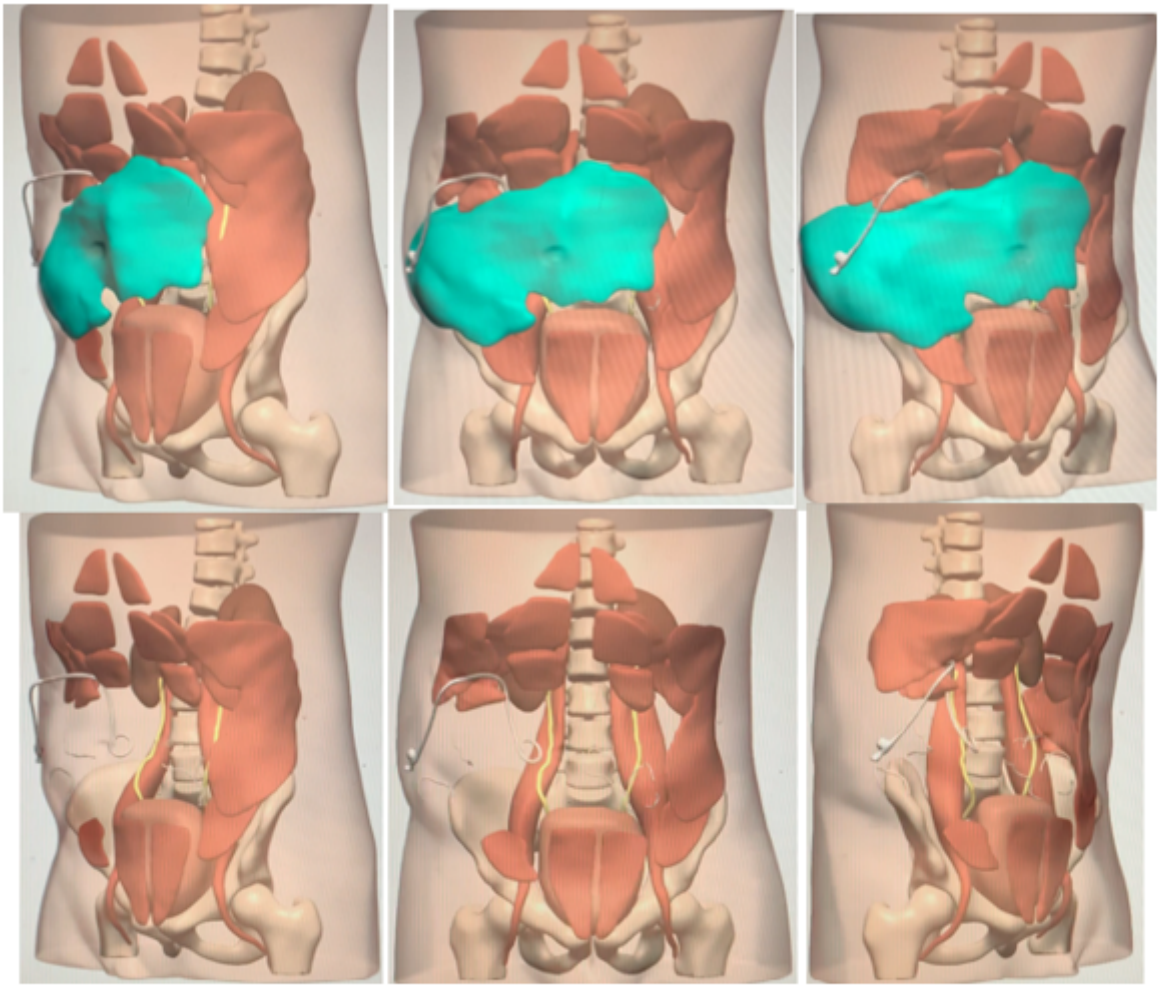

Figure 4

3D reconstruction of the abdominal wall defect

Figure 5

Status of abdominal musculature during surgery and steps of the surgical procedure performed. A. Right rectus abdominis muscle sectioned. B. Left rectus abdominis muscle sectioned. Lateral musculature reconstructed. C. Dissection of right Rives space. D. Dissection of left Rives space. E. Left Transversus Abdominis Release. F. Placement of biological mesh. G. Placement of polypropylene mesh.

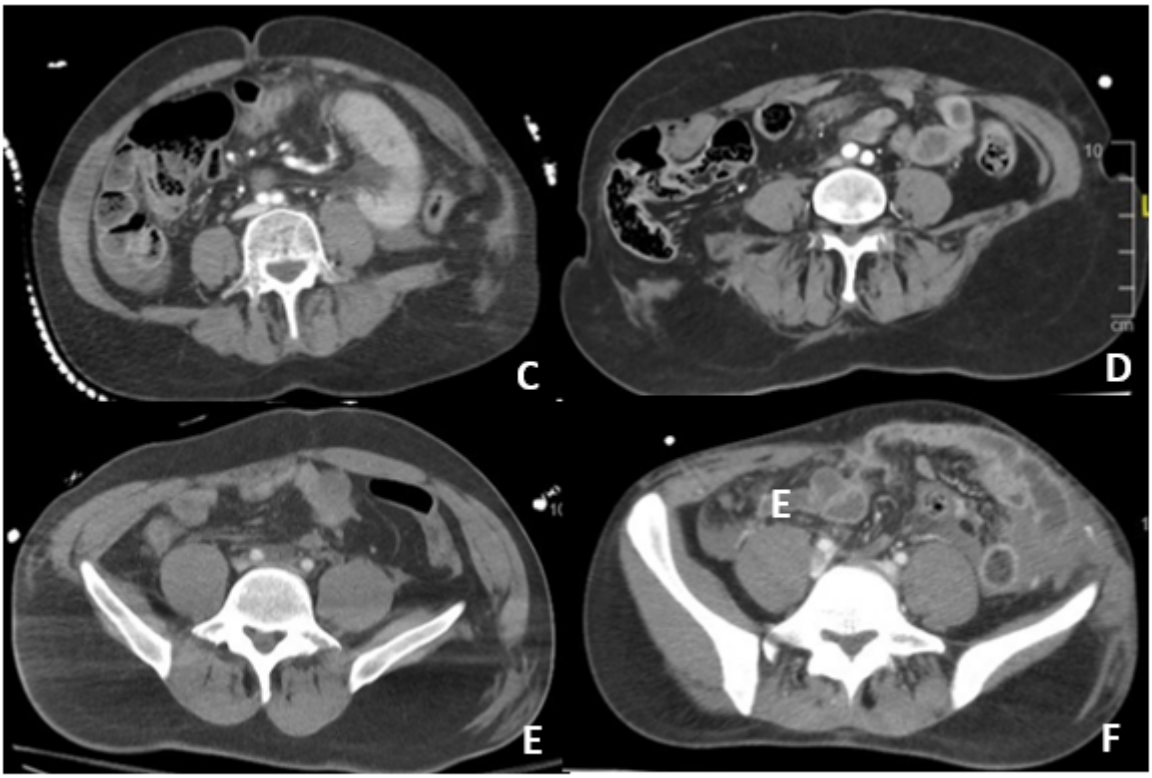

Figure 6

CT scan of patients C, D, E, and F revealing muscular laceration with traumatic hernia.