Review Article

Abdominal herniation associated with bullhorn injury as a separate entity from traumatic abdominal wall hernias

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Bullhorn injury is a rare mechanism causing traumatic abdominal wall hernia (TAWH). Bullhorn injury needs to be discussed as a separate sub-entity among TAWHs as the mechanism of injury is such that the great force is generated at a relatively small area of impact for a short duration of time which may lead to muscle defect without compromising integrity of overlying skin (referred to as sheathed goring) leading to herniation of abdominal viscera. The purpose of this review was to discuss abdominal herniation's associated with bullhorn injury as a separate entity from TAWHs; recognize the common presentations, mechanism of injury, and modalities of treatment currently utilized for this rare condition. A comprehensive online English, Spanish, Portuguese, and French language medical literature search was done using various electronic search databases. Different search terms including MeSH related to bullhorn-injury associated injuries including abdominal wall hernias were used. An advanced search was further conducted by combining all the search fields in abstracts, keywords, and titles. We summarized the data from the searched articles and found 12 cases who underwent emergency or elective herniorrhaphy with or without the use of mesh. We have proposed a treatment algorithm for such cases in light of the present era of laparoscopy and propose the usage of the term "bullhorn-injury associated traumatic hernia" for such cases. We present here the first most comprehensive discussion of all such cases reported till date.

Key words: Bullhorn-injury associated traumatic hernia, handle-bar injuries, laparoscopic repair, sheathed goring, traumatic abdominal wall hernia

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INTRODUCTION

Traumatic abdominal wall hernias (TAWHs) are relatively uncommon entities that are being reported with increasing frequencies in the current literature. Common mechanism that predispose to such hernias include motor vehicle accidents, seatbelt injuries, fall, handle-bar injuries, bullfighting, and fall of heavy objects.[1] Bullhorn injury leading to TAWH is a rare mechanism. A bull is an intact (i.e., non-castrated) adult male of the species *Bos taurus* (cattle), identified as *B. taurus indicus* or *Bos primigenius* in the Indian context and *B. taurus taurus* or *B. taurus ibericus* in Spanish bullfighting context. They are known to be more muscular and have aggressive behavior than their female counterparts, i.e., cow. Bullhorn-injury associated traumatic hernia (BATH) occurs as a result of a direct blow to the abdominal wall by the blunt horn of a bull (and related animals that include cow, ox, buffalo, and bison), which compromises the integrity of the muscles and fascia and leads to hernia formation. Only 12 such previously reported cases were found during our literature review of English, Spanish, Portuguese, and French language medical literature search.

MATERIALS AND METHODS

A comprehensive online English, Spanish, Portuguese, and French language medical literature search was

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done using various electronic search databases including the following: "Medline," "PubMed," "Embase," "Scopus," "Web of Science," "Google Scholar," "ScienceDirect," "Ovid," "Fuente Académica," "Global Index Medicus," "Index Medicus for South-East Asia Region (IMSEAR)," "IndMED," "scientific electronic library online (SciELO)," and "Latin American and Caribbean Literature on Health Sciences." Different search terms related to bullhorn associated injuries (in English as well as above-mentioned languages) were used either alone or in combination (with "and," "or") such as "bullhorn injuries," "bullhorn injury associated hernia," "bullhorn-injury associated abdominal hernia," "traumatic hernias associated with animals," "bullhorn-related traumatic hernias," "mechanism of TAWHs," "sheathed goring," "cow horn injury," "bison horn injury," "ox horn injuries," and "goring injuries." An advanced search was also carried out by combining all search fields in keywords, abstracts, and/or titles. The start date in the advanced search was kept on January 1, 1980, while the end date was October 31, 2017. Using these search terms, appropriate articles were selected for a comprehensive review. Investigation of literature was further supplemented by searching the referenced articles created by original investigators. Finally, all the selected articles were confirmed for duplications and excluded if it was observed. Google® translation service was used for translating the texts of other languages into English, and further help was taken from the Department of Linguistics, Banaras Hindu University (BHU) for proofreading and in case of any ambiguity. The outcome measures which were studied included the presentation time after injury, clinical examination findings, associated injuries, imaging findings, timing and method of operative intervention, and intra-operative findings.

RESULTS

Only 12 such previously reported cases were found during our literature review, which met the inclusion criteria mentioned above – five as case reports,[2-6] three cases as part of case series on blunt abdominal trauma,[7-9] one case as letter to editor,[10] two more cases as part of discussion on bullfight-associated injuries in Spain,[11-13] and one case as a teaching case in online radiologic teaching file.[14] Various relevant aspects of these cases have been discussed in detail in the following discussion. The comparative description of all these cases has been compiled in Table 1. We, thus, present here the first most comprehensive discussion of all such cases reported in the literature.

DISCUSSION

TAWH was first reported by Selby in 1906.[15] Dimyan *et al*. first described handlebar-associated TAWH in 1980.[16] TAWHs are relatively uncommon entities occurring with varying modes of injury. Tangential forces leading to disruption of abdominal muscles, fascia, and peritoneum is the main cause of TAWH.[17] Damschen *et al*. defined TAWH as "herniation through disrupted musculature and fascia, associated with adequate trauma, without skin penetration and no evidence of a prior hernia defect at the site of injury."[18] In contrast, bullhorn injuries are described as "sheathed goring," in which deep layers may be injured with no or minimal skin wounds due to its elastic quality, carrying a high risk of missed and severe injuries.[12,13]

BATH is a rather uncommon mechanism leading to TAWH. Injuries caused by the horn of a cow, bull, buffalo, ox, or bison would all constitute a bullhorn injury for all practical purposes; however, injuries due to the horn of a bull are the most commonly described form of horn injuries.[19] Only 12 such previously reported cases were found during our literature review[2-14] which have been summarized in Table 1. Very interestingly, most of the described incidents are from the Indian subcontinent. We were expecting a lot of reports from the Spanish, Portuguese, and French literature. However, despite the presence of several studies describing bullhorn injuries in the above-mentioned literatures,[11,13,20,21] there were hardly any reported cases of TAWH.[11,13] Martínez-Ramos *et al*. have described 387 cases related to bullhorn wounds, but there was no case describing TAWH.[21] Similarly, Ríos-Pacheco *et al*. have described their 1-year experience of dealing with cases of bullhorn injuries; however, no case of TAWH was described in there study.[20] Most of the described cases related to injuries inflicted by bull were penetrating injuries in various parts of the body. This basic difference in the nature of bullhorn-inflicted injuries leading to high chances of BATH in the Indian subcontinent as compared to bullfighting regions of the world may be explained by the characteristics of the bull found in these regions. *B. taurus indicus* or *B. primigenius* found in the Indian subcontinent has more vertical and blunt horns as compared to the relatively horizontal and sharp horns of Spanish fighting bull, i.e., *B. taurus* taurus/ibericus [Figure 1]. This leads to more penetrating injuries in bullfighting context, and that explains the relative paucity of literature related to BATH in bullfighting regions of the world.

Wood *et al*. classified TAWH in three major types: Type I is sustained from high energy injuries and are commonly associated with intra-abdominal injuries.[22] Type II occurs due to low-energy injuries example include handle-bar hernias. Type III results from deceleration injuries and is associated with intra-abdominal herniation. BATH cases can also be classified into high- and low-energy impact cases. In general, the cases with higher impact, especially when the patient was thrown away by a speeding bull, presented

Table 1: Description of all reported cases of bullhorn-injury associated traumatic hernia

	Case number 1 (Comín Novella *et al*., 2008)[11,12]	Case number 2 (Agarwal *et al*., 2009)[9]	Case number 3 (Bansal and Vyas 2010)[5]	Case number 4 (Singal *et al*., 2011)[7]	Case number 5 (Chate *et al*., 2011)[10]	Case number 6 (Chawada and Ghavghave 2013)[6]	Case number 7 (García-Marín *et al*., 2014)[13]	Case number 8 (Santa *et al*., 2015)[14]	Case number 9 (Singh *et al*., 2015)[4]	Case number 10 (Nirhale *et al*., 2015)[3]	Case number 11 (Dharap *et al*., 2016)[8]	Case number 12 (Singh *et al*., 2018)[2]
Age (years)	47	40	42	45	40	45	NA	75	70	65	50	43
Sex	Male	Female	Female	Male	Male	Male	NA	Male	Male	Male	Male	Male
Presentation time after injury	Immediately	Immediately (2 h)	Immediately (6 h)	Immediate (2 h)	Immediate	Delayed (after 8-10 days)	NA	Immediate	Immediate	Delayed (after 10 days)	Immediate (after 1 day)	Delayed (after 7 days)
Local examination	Right upper abdominal blunt injury; no apparent hernial bulge	Bruising and swelling over the right lumbar and umbilical regions with visible cough impulse. On palpation, tenderness present and an irregular defect of 8 cm appreciated	Left upper abdomen blunt injury with a bruise and visible, ill-defined tender swelling over epigastrium seen; cough impulse was present with an irregular defect of 10 cm	Tender reducible bulge present in the right iliac fossa of size 5 cm×8 cm with underlying fascial defect	Right inguinal reducible swelling with cough impulse	Partially penetrating injury over right inguinal region	NA	Thoracic and abdominal trauma	Swelling in the left lumbar region, not reducible, without definite ecchymosis	Swelling in the left lumbar and inguinal region	Right lower abdominal swelling	Resolving yellowish -brown 2×1 cm bruise; on coughing a small bulge of about 3 cm with a definite fascial defect of ~2 cm
Associated injuries	Right thoraco -abdominal injury with subcutaneous emphysema	None	None	Mesenteric tear	None	None	Retroperitoneal hematoma	Thoracic injury	Gangrene of a part of the transverse colon	None	Right pneumothorax	None

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CT/USG findings	Right multiple rib fractures in the lower region with hemothorax with herniation of bowel loops and mesenteric fat from right side of abdomen	NA	NA	USG of then abdomen revealed dilated bowel loops herniating through the defect with minimal fluid in the pelvis	8 cm defect on USG	NA	NA	CECT showed an abdominal wall hernia without entrance wound on the skin; severe mesenteric fat stranding due to the mesenteric trauma, hemoperitoneum and several active bleeding points and multiple rib fractures due to the thoracic trauma	USG - small amount of free fluid in perihepatic space, pelvis, and in between gut loops and protrusion of omentum from lateral abdominal wall	Defect in anterior abdominal wall in left lumbar region showing bowel herniation	CT revealed herniation of bowel through a defect in the anterior abdominal wall	About 2 cm defect on USG at initial presentation and <2 cm defect in anterior abdominal wall on CT done later on
Timing and location of surgical intervention	Immediately in emergency setting	Immediately in emergency setting	Immediately in emergency setting	Immediately in emergency setting	Immediately in emergency setting	In elective setting	None	NA	Immediately operated in emergency setting but hernia repair done after 3 months	In elective setting	In elective setting after 3 days	In elective setting after few weeks
Incision	Laparotomy; hernial site accessed by another incision given over the defect	Transverse laparotomy incorporating the injury site	Laparotomy	Laparotomy	Not clearly mentioned but most probably an incision over hernial site	Over the swelling in inguinal region	None	NA	Over swelling then converted to midline laparotomy as source of hemoperitoneum could not be identified	Over swelling	Laparotomy	Laparoscopic (ports - 10 mm at umbilicus; 5 mm in left iliac fossa; 5 mm in suprapubic region)

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Per-operative findings	No intra -abdominal injury	An irregular defect was found involving all subcutaneous layers of the abdominal wall	An irregular defect was found involving abdominal muscles and peritoneum	Minimal blood stained fluid and a large rent present in right lower part of the rectus muscle with mesenteric tear	All boundaries of the inguinal canal disrupted creating defect of 8 cm in posterior wall of inguinal canal	Large defect in the posterior wall of inguinal canal of about 8-10 cm with bulging of fascia transversalis along with hernia sac which contained ileal loop segment which was narrowed and was showing multiple strictures throughout its length	None	NA	Hemoperitoneum with gangrene of a part of the transverse colon in its distal 1/3 part near splenic flexure with a tear in the mesocolon	Small bowel herniating through a rent in the anterior abdominal wall musculature	Defect in anterior abdominal wall	There was no hernial sac per-say but a split defect in the muscle and fascial layers of anterior abdominal wall of <2 cm size
Treatment received	Open onlay polypropylene mesh hernioplasty	Open preperitoneal mesh hernioplasty	Open onlay mesh hernioplasty	Primary anatomic repair of defect with absorbable sutures	Open anatomic tissue repair	Resection anastomosis of ileal loop done. Redundant hernia sac returned to peritoneum and posterior wall repair done by approximation of fascia transversalis with prolene 1-0	Conservatively managed	NA	Gangrenous portion of the transverse colon was resected and converted into colostomy with repair of mesocolic tear; primary repair of hernia after 3 months	Primary anatomic tissue repair of defect	Mesh reinforcement of defect	Laparoscopic primar anatomic tissue repair using polypropylene suture
Follow-up	NA	1 year	NA	6 months	NA	5 months	NA	NA	Colostomy closure after 3 months	NA	NA	6 months
Post-operative complications	NA	None	NA	NA	NA	None	NA	NA	NA	NA	NA	None

NA=Not available; USG=Ultrasonography; CT=Computed tomography; CECT=Contrast-enhanced computed tomography

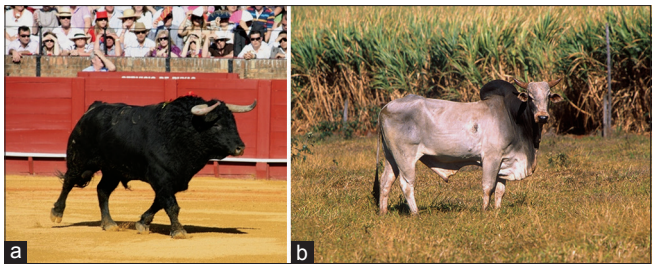

Figure 1: (a) A Spanish fighting bull (*Bos taurus* taurus/ibericus) (Courtesy: Alexander Fiskeharrison; available in public domain via wikipedia.org) with relatively horizontal and sharper horns which cause penetrating injury more commonly; (b). An Indian subcontinent bull (*Bos taurus indicus* or *Bos primigenius*) (Courtesy: Agricultural Research Service, the research agency of the United States Department of Agriculture; available in public domain via wikipedia.org) with vertical and blunt horns which cause sheathed goring more commonly

earlier[4,5,7-11,14] and may be associated with other injuries as well.[4,7,8,11] Low-impact injuries would be isolated injuries presenting late.[2,3,6] For example, in the case reported by Singh *et al*., the patient was hit by a standing bull, and he fell down on the ground and thus constitutes a low-impact type injury.[2] Had the bull been charging toward the person hitting with force, as occurs in bullfights,[11-13] the injury may be considered a high-impact injury, and the possibility of associated injuries is high. Another possible mechanism of high-impact bullhorn injury is being held by the bull in his horn and then being thrown away on to the ground or against a wall, but this mechanism might not cause the classically described BATH. In such a scenario, the probability of other forms of traumatic injuries is higher.

All reported cases of BATH were middle- to old-aged males except the cases reported by Agrawal *et al*.[9] and Bansal and Vyas[5] who were middle-aged females. The presentation in a case of TAWH caused by bullhorn that is, BATH includes pain, erythema, abrasion, bruising, laceration, bleeding, or swelling (apparent or on coughing) at the injury site. In case of injury to intra-abdominal viscera, a patient presenting immediately may present without features of peritonitis as in the case reported by Singal *et al*.[7] BATH may also present as a tender palpable lump with ecchymosis and contusion of overlying skin.[2,7] Presentation in such cases may be early (especially in high impact injuries) or delayed. BATH may be associated with extra-abdominal injuries such as pelvic, lumber, and rib fractures when significant kinetic energy is involved. Location of hernial defects was in iliac fossa, inguinal region, and lumbar region. In TAWHs, herniation is most commonly described at anatomically weak points due to blowout near iliac crest (lumbar), inguinal region, or lateral to rectus muscle away from the site of primary impact. Tension of abdominal musculature between pelvic bones increases the potential for disruption in the right lower abdomen lateral to rectus muscle through oblique and transverse muscle after blunt abdominal trauma.[22] A combination of a sudden increase in intra-abdominal pressure and powerful shear forces applied to the abdominal wall leads to TAWH.[15] The following mechanism describes the development and location of BATHs as well except that the area and time of impact are smaller.

High index of clinical suspicion is essential in all case of bullhorn abdominal injury as an accompanying hematoma often compounds the diagnosis. USG is the initial investigation most commonly employed, especially in emergency settings. It will tell about us the size of hernial defect, contents of hernial sac, presence of hemoperitoneum, and to some extent, the presence of other solid organ injuries. However, contrast-enhanced computed tomography (CECT) abdomen is the recommended investigation in all such patients even in emergency setting as hernial defect and associated injuries are identified, defined, and described with reliable sensitivity and specificity. It also tells us about the degree of disruption of abdominal wall and helps differentiate an underlying hematoma from a hernia. With the advent and availability of advanced imaging techniques in emergency setting at most tertiary centers, we recommend using CECT abdomen, in all stable BATH cases presenting immediately, for initial evaluation. As shown in Table 1, in five cases, a USG was employed, and in the other two cases, a CECT was used as a post-operative diagnostic modality. Netto *et al*. in their retrospective review of 34 patients with TAWH had made three recommendations.[23] First, mechanism of injury should be the deciding factor whether a patient with TAWH (with high energy) needs an urgent laparotomy. Second, clinically apparent hernia appears to have a high rate of associated injuries and need urgent laparotomy. Third, occult TAWH diagnosed only by CT scan may not require immediate laparotomy or hernia repair. The same principles seem to be valid for BATH cases as well. With the advent of technology, three-dimensional reconstruction of CT films is available post-operatively which can accurately quantify the size of abdominal cavity, hernial sac, and thus, helps in predicting the required mesh size.[24-27] It helps in cases planned for elective mesh repair. This technique is very useful for accurate diagnosis and differential diagnosis. However, the technology has some limitations that it is not available at all the centers, it may be difficult to employ it in emergency settings, and finally, it will have a limited role if primary tissue repair is planned as in the case reported by Singh *et al*.[2]

An algorithm has been made for the management of such cases, after reviewing recent literature on the management of TAWH and BATH, and has been presented in Figure 2. This algorithm can also be applied to cases of TAWH. In immediately presenting stable patients with a small hernial defect or occult hernial defect only demonstrable on CT scan, an initial conservative approach can be a valid

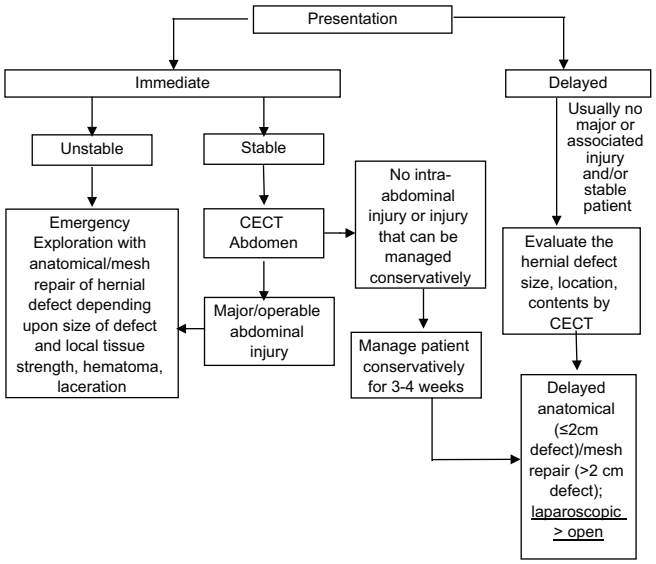

Figure 2: Management algorithm of a patient of bullhorn-injury associated traumatic hernia

entity. Although Singal *et al*.[7] and Chate *et al*.[10] have gone for immediate repair in their cases. In unstable patients or patients with injuries requiring operative intervention such as in the case of Singh *et al*.,[4] emergent laparotomy is the only option. In case of any major or operable intra-abdominal injury, patients must undergo immediate exploratory laparotomy with repair of hernial defect anatomically as in case of Singal *et al*.[7] or using a mesh in the same sitting. However, in the case of Singh *et al*.,[4] repair of hernial defect was not done at the initial laparotomy rather it was done as an anatomical repair 3 months later along with colostomy closure. No reason has been mentioned regarding this odd choice, but a possible explanation may be that the local tissue might been injured in such a way that it precluded any immediate repair. In stable patients, not requiring any immediate surgical intervention and having small hernial defect on CT in the absence of any associated injury, we found that going for a delayed repair after few weeks appears to be a wise choice because it gives time for resolution of local edema, hematoma, and inflammation as described by Singh *et al*.[2] Chate *et al*. have chosen to repair the 8 cm defect in the right inguinal region immediately.[10] In delayed presentations, usually, there is no associated injuries and patient is stable.

Regarding incision in cases of open hernioplasty in BATH, an incision over hernia swelling in elective cases delayed cases, and selected cases in emergency setting (with no other suspected injury on pre-operative imaging), remains a favored option. It appears to be a logical decision to go for a local incision over hernial site for repairing the defect if open hernioplasty is planned in elective setting. Even if any associated injury is suspected on CECT, a diagnostic laparoscopy followed by a laparoscopic or open repair is a wise move. We found it odd that Dharap *et al*. went for laparotomy in elective setting even after having done a CT scan.[8] Issues related to the availability of technical expertise in laparoscopy might be a possible explanation. A diagnostic laparoscopy for any suspected injury followed by laparoscopic or open hernia repair by an incision over swelling would have been a better decision under the mentioned circumstances.

Only Dharap *et al*., who had done repair in elective setting has used mesh for repair.[8] Nirhale *et al*. have also operated the patient in elective setting, but he has chosen for anatomic repair.[3] Other authors have operated the patient in the emergency setting and have gone for the more common notion of avoiding mesh and doing the anatomic repair.[7,10] We also avoid mesh in emergency settings. However, Comín Novella *et al*.,[11] Agarwal *et al*.[9] and Bansal and Vyas[5] have gone for a mesh repair in an emergency setting. García-Marín *et al*. have shown that the patient was managed conservatively, but they have not mentioned the follow-up so the patient might have undergone hernioplasty later on.[13]

There has been an ongoing debate regarding the timing of repair, that is, early versus delayed repair of TAWHs.[28-30] Early repair has been the most commonly reported entity in literature, and its proponents say that with delayed repair defects may enlarge, muscle may undergo disuse atrophy, primary approximation may become difficult and other injuries may be missed. However, more recently, delayed repairs of TAWHs in stable patients have been reported with optimal outcomes.[28,29,31] Singh *et al*. have described a clean hernial defect with no tissue edema or inflammation peroperatively on delayed repair, due to which laparoscopic anatomic repair of defect was done very easily.[2] This fact is further reinforced by the case reported by Singh *et al*., as the authors did not repair the hernial defect at initial operation even though they started the operation by an incision over the defect and then converted it into a midline laparotomy.[4] Only logical explanation appears to be poor condition of tissue locally (possible laceration/shattering) and contamination which precluded any immediate repair. We strongly advocate going for an interval elective repair of small hernial defects in stable patients but within a few weeks, as this gives time for local tissue edema and inflammation to subside off and fibrosis to set in. Very small defects can heal off over due course of time and size of defects might reduce as occurred with the case described by Singh *et al*.[2]

Laparoscopic repair of TAWH has been described with reliable repair of defects and optimal outcome, but in almost, all cases mesh repair was the preferred option.[32-34] Singh *et al*.[2] have described a case where they have successfully used laparoscopic anatomic tissue

repair with nonabsorbable suture and is the first case of BATH employing principles of laparoscopy. Finally, there is no documented complication following BATH repair at present, but this may be due to a lack of long-term follow-up. Honaker *et al*. reported a recurrence rate of 8.3% in 38 cases of TAWH, with all the recurrences occurring in patients undergoing immediate repair.[35] Similarly, Coleman *et al*. have reported a recurrence rate of 26% for TAWH, in his case, series of 80 patients with acute repair being associated with the majority of the recurrences.[36] Even Damschen *et al*. recognized that immediate surgery does not prevent late sequelae.[18] This again reinforces the concept of relatively delayed repair in stable patients with small defect and delayed presentation.

CONCLUSION

Bullhorn injury is an uncommon mechanism of the development of TAWH and may present immediately or as delayed presentation. Patients presenting late but with stable vitals and small hernial defects can be managed by delayed elective hernial defect repair and utilizing laparoscopic principles is a valid and feasible option. In the present era of minimal access surgery, if facilities and expertise permit, laparoscopic principles must be utilized in emergency as well as elective settings for the management of TAWHs and BATHs for the optimal patient outcome and to minimize post-operative morbidity.

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Conflicts of interest

There are no conflicts of interest.

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