

World Journal of *Clinical Cases*

World J Clin Cases 2022 October 16; 10(29): 10391-10822



Contents

Thrice Monthly Volume 10 Number 29 October 16, 2022

STANDARD AND CONSENSUS

- 10391** Baishideng's *Reference Citation Analysis* database announces the first *Article Influence Index* of multidisciplinary scholars
Wang JL, Ma YJ, Ma L, Ma N, Guo DM, Ma LS

REVIEW

- 10399** Cholecystectomy for asymptomatic gallstones: Markov decision tree analysis
Lee BJH, Yap QV, Low JK, Chan YH, Shelat VG
- 10413** Liver transplantation for hepatocellular carcinoma: Historical evolution of transplantation criteria
Ince V, Sahin TT, Akbulut S, Yilmaz S

MINIREVIEWS

- 10428** Prostate only radiotherapy using external beam radiotherapy: A clinician's perspective
Lee JW, Chung MJ

ORIGINAL ARTICLE

Retrospective Study

- 10435** Age-adjusted NT-proBNP could help in the early identification and follow-up of children at risk for severe multisystem inflammatory syndrome associated with COVID-19 (MIS-C)
Rodriguez-Gonzalez M, Castellano-Martinez A
- 10451** Clinicopathological characteristics and prognosis of gastric signet ring cell carcinoma
Tian HK, Zhang Z, Ning ZK, Liu J, Liu ZT, Huang HY, Zong Z, Li H
- 10467** Development and validation of a prognostic nomogram for decompensated liver cirrhosis
Zhang W, Zhang Y, Liu Q, Nie Y, Zhu X

Observational Study

- 10478** Effect of medical care linkage-continuous management mode in patients with posterior circulation cerebral infarction undergoing endovascular interventional therapy
Zhu FX, Ye Q
- 10487** Effect of the COVID-19 pandemic on patients with presumed diagnosis of acute appendicitis
Akbulut S, Tuncer A, Ogut Z, Sahin TT, Koc C, Guldogan E, Karabulut E, Tanriverdi ES, Ozer A

EVIDENCE-BASED MEDICINE

- 10501** Delineation of a SMARCA4-specific competing endogenous RNA network and its function in hepatocellular carcinoma

Zhang L, Sun T, Wu XY, Fei FM, Gao ZZ

SYSTEMATIC REVIEWS

- 10516** Comparison of laboratory parameters, clinical symptoms and clinical outcomes of COVID-19 and influenza in pediatric patients: A systematic review and meta-analysis

Yu B, Chen HH, Hu XF, Mai RZ, He HY

CASE REPORT

- 10529** Surgical treatment of bipolar segmental clavicle fracture: A case report

Liang L, Chen XL, Chen Y, Zhang NN

- 10535** Multiple disciplinary team management of rare primary splenic malignancy: Two case reports

Luo H, Wang T, Xiao L, Wang C, Yi H

- 10543** Klippel-Trenaunay-Weber syndrome with ischemic stroke: A case report

Lee G, Choi T

- 10550** Vedolizumab in the treatment of immune checkpoint inhibitor-induced colitis: Two case reports

Zhang Z, Zheng CQ

- 10559** Novel way of patent foramen ovale detection and percutaneous closure by intracardiac echocardiography: A case report

Han KN, Yang SW, Zhou YJ

- 10565** Treatment failure in a patient infected with *Listeria* sepsis combined with latent meningitis: A case report

Wu GX, Zhou JY, Hong WJ, Huang J, Yan SQ

- 10575** Three-in-one incidence of hepatocellular carcinoma, cholangiocellular carcinoma, and neuroendocrine carcinoma: A case report

Wu Y, Xie CB, He YH, Ke D, Huang Q, Zhao KF, Shi RS

- 10583** Intestinal microbiome changes in an infant with right atrial isomerism and recurrent necrotizing enterocolitis: A case report and review of literature

Kaplina A, Zaikova E, Ivanov A, Volkova Y, Alkhova T, Nikiforov V, Latypov A, Khavkina M, Fedoseeva T, Pervunina T, Skorobogatova Y, Volkova S, Ulyantsev V, Kalinina O, Sitkin S, Petrova N

- 10600** *Serratia fonticola* and its role as a single pathogen causing emphysematous pyelonephritis in a non-diabetic patient: A case report

Villasuso-Alcocer V, Flores-Tapia JP, Perez-Garfias F, Rochel-Perez A, Mendez-Dominguez N

- 10606** Cardiac myxoma shedding leads to lower extremity arterial embolism: A case report

Meng XH, Xie LS, Xie XP, Liu YC, Huang CP, Wang LJ, Zhang GH, Xu D, Cai XC, Fang X

- 10614** Extracorporeal membrane oxygenation in curing a young man after modified Fontan operation: A case report
Guo HB, Tan JB, Cui YC, Xiong HF, Li CS, Liu YF, Sun Y, Pu L, Xiang P, Zhang M, Hao JJ, Yin NN, Hou XT, Liu JY
- 10622** Wandering small intestinal stromal tumor: A case report
Su JZ, Fan SF, Song X, Cao LJ, Su DY
- 10629** Acute mesenteric ischemia secondary to oral contraceptive-induced portomesenteric and splenic vein thrombosis: A case report
Zhao JW, Cui XH, Zhao WY, Wang L, Xing L, Jiang XY, Gong X, Yu L
- 10638** Perioperative anesthesia management in pediatric liver transplant recipient with atrial septal defect: A case report
Liu L, Chen P, Fang LL, Yu LN
- 10647** Multiple tophi deposits in the spine: A case report
Chen HJ, Chen DY, Zhou SZ, Chi KD, Wu JZ, Huang FL
- 10655** Myeloproliferative neoplasms complicated with β -thalassemia: Two case report
Xu NW, Li LJ
- 10663** Synchronous renal pelvis carcinoma associated with small lymphocytic lymphoma: A case report
Yang HJ, Huang X
- 10670** *Leclercia adecarboxylata* infective endocarditis in a man with mitral stenosis: A case report and review of the literature
Tan R, Yu JQ, Wang J, Zheng RQ
- 10681** Progressive ataxia of cerebrotendinous xanthomatosis with a rare c.255+1G>T splice site mutation: A case report
Chang YY, Yu CQ, Zhu L
- 10689** Intravesical explosion during transurethral resection of bladder tumor: A case report
Xu CB, Jia DS, Pan ZS
- 10695** Submucosal esophageal abscess evolving into intramural submucosal dissection: A case report
Jiao Y, Sikong YH, Zhang AJ, Zuo XL, Gao PY, Ren QG, Li RY
- 10701** Immune checkpoint inhibitor-associated arthritis in advanced pulmonary adenocarcinoma: A case report
Yang Y, Huang XJ
- 10708** Chondroid syringoma of the lower back simulating lipoma: A case report
Huang QF, Shao Y, Yu B, Hu XP
- 10713** Tension-reduced closure of large abdominal wall defect caused by shotgun wound: A case report
Li Y, Xing JH, Yang Z, Xu YJ, Yin XY, Chi Y, Xu YC, Han YD, Chen YB, Han Y

- 10721** Myocardial bridging phenomenon is not invariable: A case report
Li HH, Liu MW, Zhang YF, Song BC, Zhu ZC, Zhao FH
- 10728** Recurrent atypical leiomyoma in bladder trigone, confused with uterine fibroids: A case report
Song J, Song H, Kim YW
- 10735** Eczema herpeticum *vs* dermatitis herpetiformis as a clue of dedicator of cytokinesis 8 deficiency diagnosis: A case report
Alshengeti A
- 10742** Cutaneous allergic reaction to subcutaneous vitamin K₁: A case report and review of literature
Zhang M, Chen J, Wang CX, Lin NX, Li X
- 10755** Perithyroidal hemorrhage caused by hydrodissection during radiofrequency ablation for benign thyroid nodules: Two case reports
Zheng BW, Wu T, Yao ZC, Ma YP, Ren J
- 10763** Malignant giant cell tumors of the tendon sheath of the right hip: A case report
Huang WP, Gao G, Yang Q, Chen Z, Qiu YK, Gao JB, Kang L
- 10772** Atypical Takotsubo cardiomyopathy presenting as acute coronary syndrome: A case report
Wang ZH, Fan JR, Zhang GY, Li XL, Li L
- 10779** Secondary light chain amyloidosis with Waldenström's macroglobulinemia and internodal marginal zone lymphoma: A case report
Zhao ZY, Tang N, Fu XJ, Lin LE
- 10787** Bilateral occurrence of sperm granulomas in the left spermatic cord and on the right epididymis: A case report
Ly DY, Xie HJ, Cui F, Zhou HY, Shuang WB
- 10794** Glucocorticoids combined with tofacitinib in the treatment of Castleman's disease: A case report
Liu XR, Tian M
- 10803** Giant bilateral scrotal lipoma with abnormal somatic fat distribution: A case report
Chen Y, Li XN, Yi XL, Tang Y
- 10811** Elevated procalcitonin levels in the absence of infection in procalcitonin-secreting hepatocellular carcinoma: A case report
Zeng JT, Wang Y, Wang Y, Luo ZH, Qing Z, Zhang Y, Zhang YL, Zhang JF, Li DW, Luo XZ

LETTER TO THE EDITOR

- 10817** "Helicobacter pylori treatment guideline: An Indian perspective": Letter to the editor
Swarnakar R, Yadav SL
- 10820** Effect of gender on the reliability of COVID-19 rapid antigen test among elderly
Nori W, Akram W

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RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Hua-Ge Yin; Production Department Director: Xiang Li; Editorial Office Director: Jin-Lei Wang.

NAME OF JOURNAL

World Journal of Clinical Cases

ISSN

ISSN 2307-8960 (online)

LAUNCH DATE

April 16, 2013

FREQUENCY

Thrice Monthly

EDITORS-IN-CHIEF

Bao-Gan Peng, Jerzy Tadeusz Chudek, George Kontogeorgos, Maurizio Serati, Ja Hyeon Ku

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/2307-8960/editorialboard.htm>

PUBLICATION DATE

October 16, 2022

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INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



Tension-reduced closure of large abdominal wall defect caused by shotgun wound: A case report

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Specialty type: Medicine, research and experimental

Provenance and peer review:

Unsolicited article; Externally peer reviewed

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B, B
Grade C (Good): 0
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Musoni L, Morocco; Zharikov YO, Russia

Received: May 10, 2022

Peer-review started: May 10, 2022

First decision: July 13, 2022

Revised: July 19, 2022

Accepted: September 8, 2022

Article in press: September 8, 2022

Published online: October 16, 2022



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Abstract

BACKGROUND

Large abdominal wall defect (LAWD) caused by shotgun wound is rarely reported.

CASE SUMMARY

Herein, we describe a case of LAWD caused by a gunshot wound in which the abdominal wall was reconstructed in stages, including debridement, tension-reduced closure (TRC), and reconstruction with mesh and a free musculocutaneous flap. During a 3-year follow-up, the patient recovered well without hernia or other problems.

CONCLUSION

TRC is a practical approach for the temporary closure of LAWD, particularly in cases when one-stage abdominal wall restoration is unfeasible due to significant comorbidities.

Key Words: Free flap; Shotgun; Hernia; Large abdominal wall defect; Tension relief closure; Mesh; Case report

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Core Tip: The large full-thickness abdominal defect caused by gunshot wound is often associated with infection, multiorgan injuries, and poor patient conditions. Tension-reduced closure is a useful method for the temporary closure of large abdominal wall defect, particularly in cases in which one-stage abdominal wall reconstruction is unfeasible.

Citation: Li Y, Xing JH, Yang Z, Xu YJ, Yin XY, Chi Y, Xu YC, Han YD, Chen YB, Han Y. Tension-reduced closure of large abdominal wall defect caused by shotgun wound: A case report. *World J Clin Cases* 2022; 10(29): 10713-10720

URL: <https://www.wjgnet.com/2307-8960/full/v10/i29/10713.htm>

DOI: <https://dx.doi.org/10.12998/wjcc.v10.i29.10713>

INTRODUCTION

Large abdominal wall defect (LAWD) is commonly caused by tumor resection, followed by infection, trauma, and radiation-induced injury[1]. LAWD caused by gunshot wound has been rarely reported in the previous literature[2]. Gunshot wounds often lead to full-thickness defects, infection, multiorgan injuries, and poor patient conditions making reconstruction of LAWD extremely challenging[3]. Conventional one-stage reconstruction with mesh reinforcement plus free flap may be unfeasible and staged reconstruction is required[4].

Tension-reduced closure (TRC) is a novel technique for the closure of large wounds by reducing the tension across the wound edges based on the theories of stress relaxation and mechanical creep for skin stretching[5]. Previous studies have shown that TRC is a simple, effective, and safe method for wound closure for a variety of reasons. However, no study to date has reported the use of TRC for LAWD caused by a gunshot wound. Here, we report a case of gunshot LAWD, who underwent staged abdominal wall reconstruction including debridement, temporary TRC, and definitive reconstruction with prosthetic mesh plus a free flap.

CASE PRESENTATION

Chief complaints

Abdominal wall hernia formation after abdominal gunshot wound.

History of present illness

A 44-year old man presented with a large abdominal bulge. He was robbed and shot in the abdomen in South Africa 1.5 years ago, resulting in open abdomen, hemorrhagic shock, infection, intestinal exposure, and severe multiorgan injuries involving the transverse colon, greater omentum, spleen, diaphragm, and left kidney. Emergency surgeries including removal of bullets and foreign body, debridement, transverse colectomy, omentectomy, nephrectomy, and colostomy were performed at a local hospital in South Africa. The large full-thickness abdominal wall defect was initially covered by split-thickness skin mesh grafting on intestines harvested from the left thigh.

History of past illness

The patient had hepatitis and underwent left kidney removal after a gunshot wound on July 26, 2017.

Personal and family history

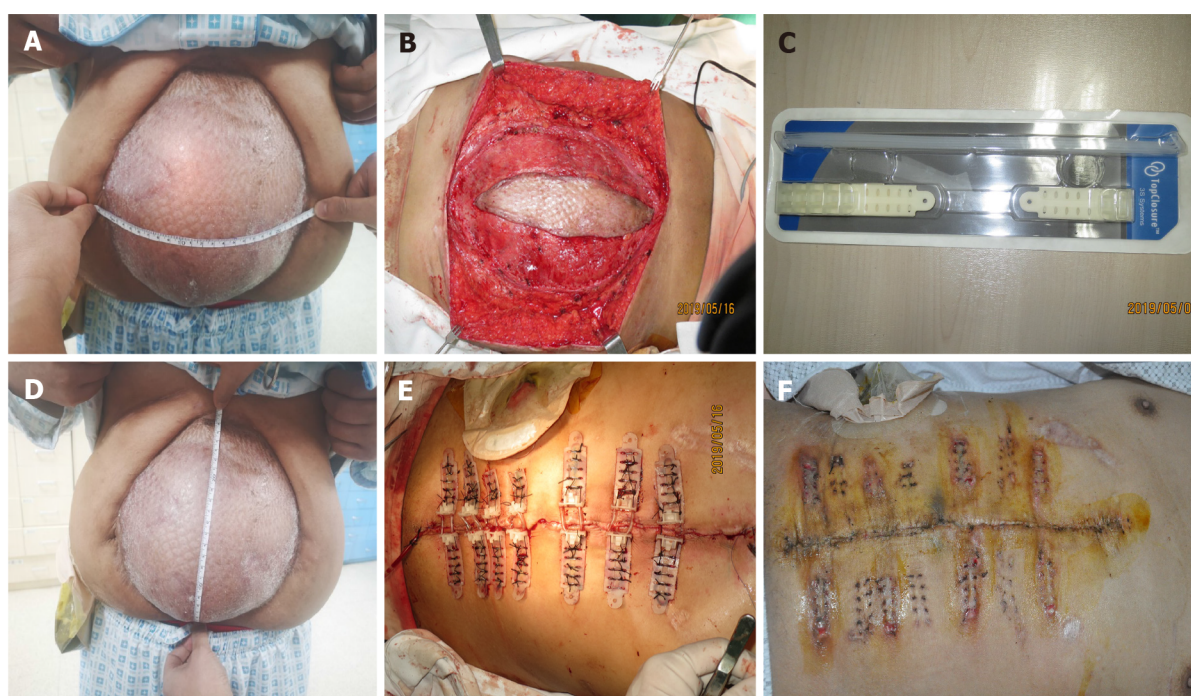
The patient denied a family history of infectious and genetic diseases.

Physical examination

The patient developed a large abdominal hernia and was referred to our hospital for abdominal reconstruction 1.5 years after the initial injury. A 26 cm × 28 cm full thickness abdominal defect covered with grafted skin mesh was found at the first consultation. The hernia was protruding when he was standing or lying on one side. Underlying peristalsis was observed. A colostomy stoma was located at 10 cm close to the skin grafts and connected with a colostomy bag.

Laboratory examinations

Laboratory examinations showed no significant abnormalities.



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Figure 1 The patient's first preoperative, intraoperative, and postoperative conditions in our department. A: Length of the abdominal bulge when the patient was standing; B: Width of the abdominal bulge when the patient was standing; C: Grafted skin of the abdomen was carefully removed; D: Immediate primary closure was achieved, utilizing 7 Top Closure® and 8 mm sets; E: Top Closure® 1S 8 mm sets; F: Tension Relief System was removed 3 wk after installation.

Imaging examinations

Ultrasound examination results were consistent with changes in the abdominal wall defect after trauma.

FINAL DIAGNOSIS

The final diagnosis were postoperative abdominal wall trauma, abdominal wall defect, and abdominal wall hernia.

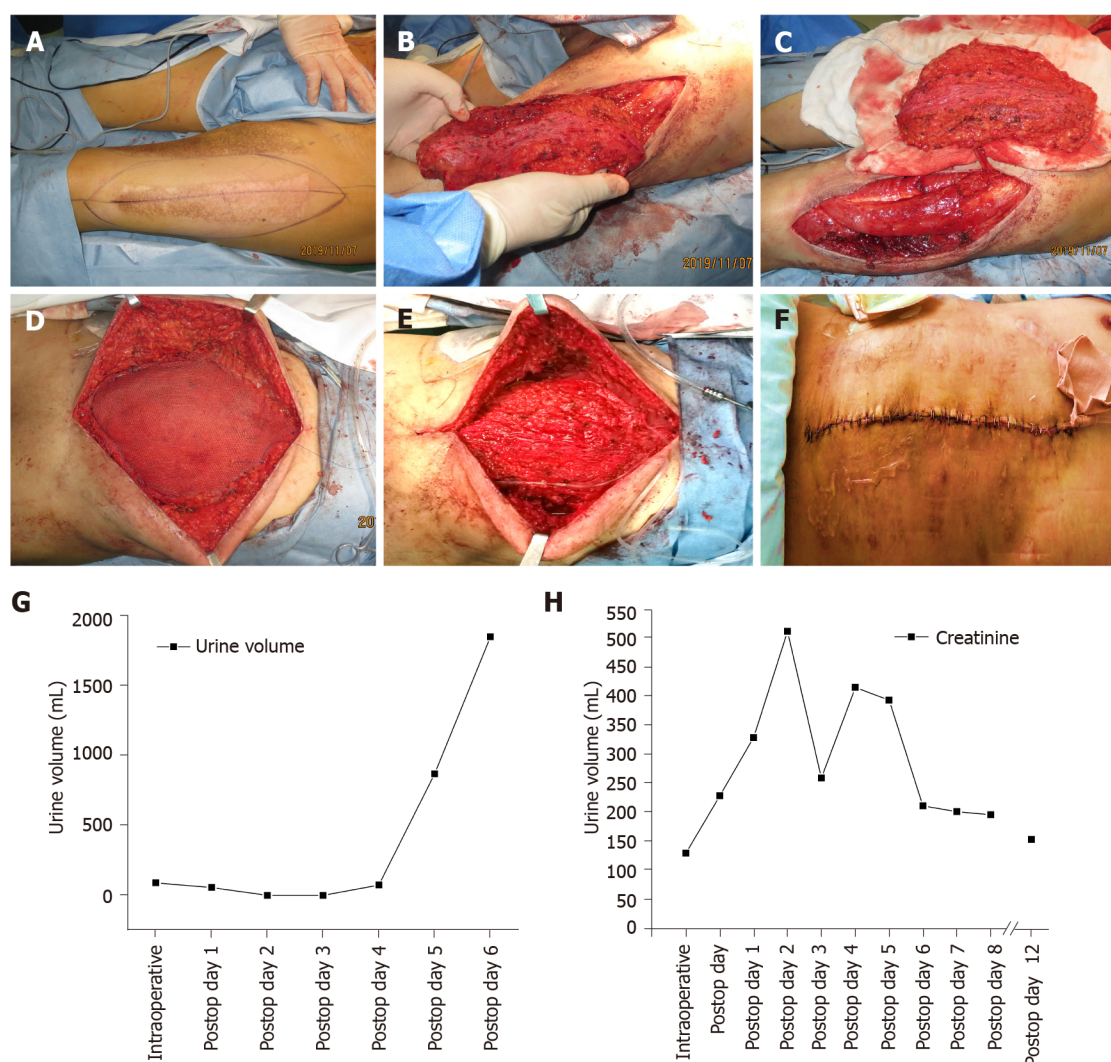
TREATMENT

TRC

One-stage abdominal reconstruction was unfeasible due to the patient's comorbidities and poor condition. The colostomy stoma may increase the risk of infection. Therefore, we carefully removed the grafted skin. The area of LAWD was 21 cm × 22 cm after the removal of the grafted skin. The operation duration was prolonged to 5.5 h due to the large area of severe adhesion between the grafted skin and viscera. Oliguria (urine volume < 90 mL) occurred during surgery owing to the mononephrous dysfunction, right renal pelvis stone, and ureteral obstruction diagnosed by ultrasonography. To reduce operation duration and surgical risks, a temporary TRC of the defect was performed using the Tension Relief System (TRS, Top Closure® 1S 8 mm sets, IVT Medical Limited, Israel). Briefly, seven pairs of attachment plates were placed 2 cm away from the wound edges and anchored with 3-0 silk sutures (Mersilk, Ethicon, United States) and staples (PROXIMATE, Ethicon, United States). Incremental approximation of wound edges was archived by pulling the bridging approximation straps through a lock/release ratchet mechanism (Figure 1). The patient developed hydronephrosis with a maximum blood creatinine level up to 511.3 μmol/L. He underwent hemofiltration dialysis and renal pelvis catheterization for 2 wk. The change in urine volume and creatinine is shown in Figure 2. The abdominal wound healed well without dehiscence or necrosis and TRS was removed 3 wk after installation.

Mesh reinforcement and anterolateral thigh flap reconstruction

Five months later, the patient underwent abdominal wall reconstruction with mesh reinforcement and a free anterolateral thigh (ALT) musculofascial flap to definitively repair his hernia (Figure 2). The original incision was reopened. Component separation was performed. The 15 cm × 20 cm peritoneal



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Figure 2 The patient's surgical procedure and the dynamic changes in biochemical indicators. A: The anterolateral thigh perforator (ALT) flap was designed preoperatively according to the size of the defect in the recipient area; B: The skin and subcutaneous tissue were incised and the ALT flap was separated from the surrounding tissue; C: The ALT flap was freed and the tip was broken; D: Mesh was used to reinforce the abdominal wall hernia; E: ALT flap was grafted to the abdomen and vascular anastomosis was performed; F: The abdominal wound was closed and the abdominal skin was sutured; G: The patient's volume of urine changes over time; H: The patient's creatinine values over time.

defect was repaired with a 20 cm × 20 cm hydrophilic mesh (Covidien, United States). The coverage ranged from the xiphoid and 2 cm inferior to the costal arch to 10 cm superior to the pubic symphysis vertically, and bilateral aponeurosis of external obliques horizontally. The mesh was secured with lock-stitch PDS II suturing. A 15 cm × 20 cm ATL musculofascial flap was elevated. The pedicle of descending branch of the lateral circumflex femoral artery was 14 cm. The microvascular anastomosis was performed on a branch of the superficial epigastric artery (Figure 2). The ALT flap was covered on the prosthetic mesh to repair the soft tissue defect (Figure 3).

OUTCOME AND FOLLOW-UP

The patient was followed for 3 years. He recovered well and reported significant improvement in quality of life without signs of hernial recurrence (Figure 4).

DISCUSSION

Shotgun wounds, a high-energy firearm injury, often result in trauma contamination, extensive tissue contusions, and open injuries that make treatment difficult[6-8]. Current treatment principles regarding shotgun wounds include initial debridement followed by wound closure to prevent damage to deep

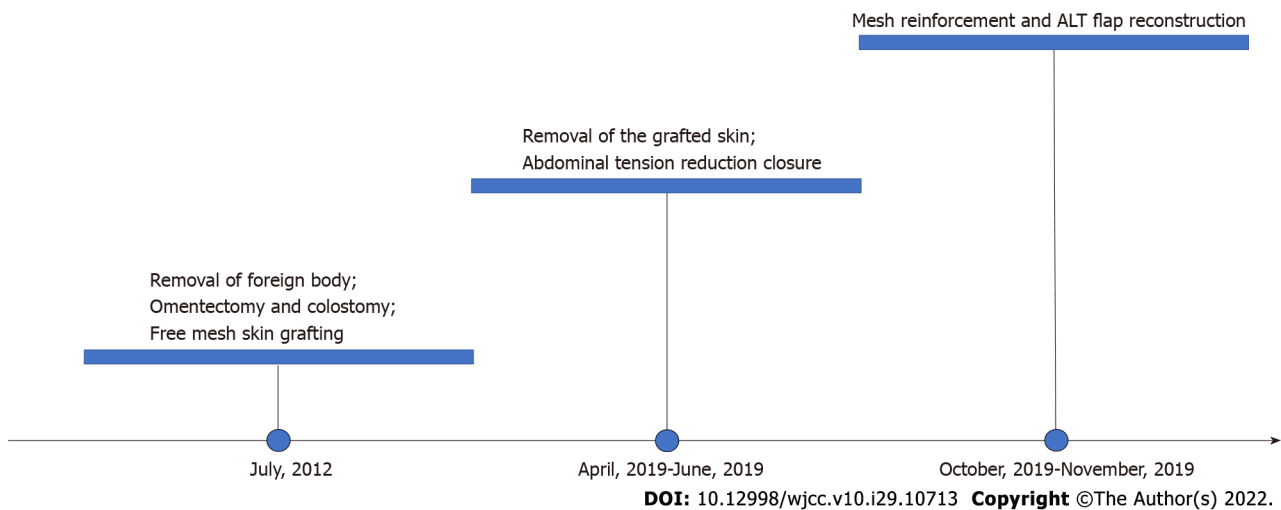
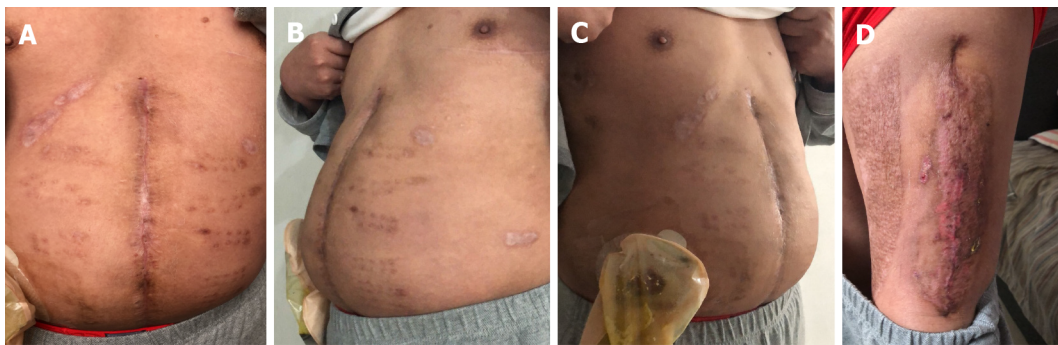


Figure 3 Timeline of treatment events. ALT: Anterolateral thigh perforator.



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Figure 4 One year following surgery, the patient recovered well and reported significant improvement in quality of life without signs of hernial recurrence.

tissue. However, closure of the wound should be delayed until 15 d in patients with more severe contamination[9]. Further treatment is feasible after the patient's vital signs have stabilized. The case that we report had a temporary local trauma closure due to multiple shotgun wounds throughout the body, resulting in a LAWD, multiple organ damage, and poor general condition. For the further resolution of the abdominal wall hernia, he came to our department for treatment.

Many techniques for reconstruction of LAWD have been reported, but this is to date the first case of staged reconstruction with temporary TRC and definitive reconstruction with mesh and a flap. Gu *et al* [10] summarized the methods for abdominal wall reconstruction, including suture[11], prosthetic material[12], component separation technique[13], autologous tissue reconstruction[14], and abdominal wall expansion[15]. However, none of these methods could be used during the first reconstructive surgery owing to the patient's poor conditions. Therefore, we used a commercial TRS for temporary abdominal closure[16].

The TRS was a novel method for large wound closure. Topaz *et al*[5] first introduced the use of TRS in 20 patients for preoperative skin stretching or intraoperative wound closure. Their study presented many cases who underwent TRS for larger defect closure after malignancy resection[17,18]. Dan *et al*[19] reported two cases of using TRS for wound closure of high-tension flap donor site following the harvest of deep inferior epigastric perforator flap and ALT flap. Choke *et al*[20] described their successful experience of using TSR and vacuum-assisted closure techniques for the treatment of extensive soft tissue defects in four patients. Similarly, Li *et al*[21] used a combined treatment with vacuum sealing drainage, TRS, and Ilizarov technique for traumatic hemipelvectomy in one case. The patient was able to ambulate and perform activities of daily life at the follow-up visit. Zhu *et al*[22] reported a 61-year-old man with bladder exstrophy who received primary closure of a large abdominal defect using TRS. In addition, a simulation study using finite element modeling by Katzungold *et al*[23] showed that the tensile stress generated by the TRS was only 4% of that generated by conventional sutures, suggesting that TRS significantly reduced local tissue deformations and stress concentrations during large wound closure. These studies have demonstrated that TRS reduced operative time, length of hospital stay, and

Table 1 Details of cases treated with Tension Relief System

Ref.	Case no.	Age (yr)	Gender (male/female)	Cause of defect	Region of defect	Size of defect	Application time (prior to, during, and/or after surgery)	Closure (immediate/delayed closure)	Time to closure (min/d)
Topaz <i>et al</i> [5], 2012	1	62	Male	SCC	Left distal leg	3 cm × 2 cm	Prior to surgery	Delayed	16 d
	2	52	Female	Scar	Lower abdominal	7 cm × 8 cm	Prior to surgery	Delayed	11 d
	3	26	Male	High-voltage electric burn	Left lower limb	NA	During surgery	Immediate	NA
	4	12	Female	Congenital nevus	Right thigh	Φ = 2 cm	Prior to surgery	Delayed	14 d
	5	29	Female	Infected surgical wound	Abdominal	NA	NA	Delayed	NA
	6	88	Female	SCC	Left distal leg	Φ = 2.5 cm	Prior to surgery	Delayed	12 d
Topaz <i>et al</i> [17], 2014	7	64	Male	BCC	Parietal scalp	Φ = 3.5 cm	After surgery	Delayed	5 d
	8	64	Male	BCC	Parietal scalp	Φ = 3 cm	After surgery	Delayed	1 d
	9	74	NA	SCC	Frontal scalp	Φ = 3 cm	During surgery	Immediate	NA
	10	78	NA	Ulcerated BCC	Occipital scalp	Φ = 3.2 cm	After surgery	Delayed	5 d
	11	17	NA	Scar tissue neoplasia	Parietal scalp	Φ = 2.5 cm	After surgery	Delayed	2 d
	12	95	Male	SCC	Occipital scalp	Φ = 4.5 cm	After surgery	Delayed	17 d
	13	82	NA	SCC	Parietal scalp	Φ = 3.5 cm	After surgery	Delayed	21 d
	14	82	NA	SCC	Occipital scalp	Φ = 3 cm	After surgery	Delayed	2 d
	15	65	NA	SCC	Occipital scalp	Φ = 4 cm	After surgery	Delayed	5 d
Topaz <i>et al</i> [18], 2014	16	60	Male	Basal cell carcinoma	Flank	15 cm × 25 cm	During surgery	Immediate	26 min
	17	35	Male	Malignant melanoma	Scapular	7 cm × 11.5 cm	During surgery	Immediate	60 min
	18	41	Male	Spindle cell sarcoma	Supraclavicular	26 cm × 25 cm	During surgery	Immediate	135 min
Dan <i>et al</i> [19], 2015	19	20	Female	Tumor	Left groin	10 cm × 8 cm	After surgery	Delayed	28 d
	20	53	Male	Traffic accident	Foot and ankle	10 cm × 9 cm	After surgery	Delayed	15 d
Zhu <i>et al</i> [22], 2020	21	3	Female	Infantile hemangiomas	Scalp	6.5 cm × 5.2 cm	During surgery	Immediate	20 min
Choke <i>et al</i> [20], 2017	22	42	Male	Bacterial infection	Limb	91 cm × 17 cm	After surgery	Delayed	60 d
	23	55	Male	Sternal osteomyelitis	Chest	28 cm × 8 cm	After surgery	Delayed	42 d
	24	29	Male	Hernia	Abdomen	9 cm × 10 cm	After surgery	Delayed	28 d
Li <i>et al</i> [21],	25	4	Female	Traffic accident trauma	Pubic symphysis	14 cm × 9 cm	After surgery	Delayed	NA

SCC: Squamous cell carcinoma; BCC: Basal cell carcinoma; NA: Not available.

costs, improved wound aesthetics, and minimized complications and obviated donor site morbidity caused by conventional skin grafting or flap reconstruction (Table 1).

There are several advantages of using TRS. First, TRS narrowed the width of the abdominal wall defect, thus reducing the flap area in the final abdominal reconstruction from 26 cm × 28 cm to 15 cm × 25 cm. Second, the operation time and associated risks were significantly reduced. The abdomen was successfully closed within 40 min using TRC, compared to hours of operation time for conventional reconstruction[24]. At the last follow-up, the patient reported satisfaction with his treatment owing to significant improvement in quality of life without signs of hernial recurrence.

CONCLUSION

The large full-thickness abdominal defect caused by a gunshot wound is often associated with infection, multiorgan injuries, and poor patient conditions. TRC is a useful method for the temporary closure of LAWD, particularly in cases in which one-stage abdominal wall reconstruction is unfeasible.

FOOTNOTES

Author contributions: Li Y and Xing JH contributed equally to this work and as co-first author; Han Y and Chen YB as co-corresponding author of this study; Li Y, Xing JH, and Yang Z wrote the main manuscript text and prepared all the figures; Xu YC, Chen YB, Han YD, and Han Y suggested ideas and steps for the article; Xu YJ, Yin XY, and Chi Y participated in the revision of part of the article; and all authors read and approved the final manuscript.

Informed consent statement: Written informed consent was obtained from the patient for the publication of this case report and any accompanying images.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

CARE Checklist (2016) statement: The authors have read the CARE Checklist (2016), and the manuscript was prepared and revised according to the CARE Checklist (2016).

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S-Editor: Wang JJ

L-Editor: Wang TQ

P-Editor: Wang JJ

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