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The temporary abdominal closure techniques used for trauma patients: a systematic review and meta-analysis

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Purpose: The choice of temporary abdominal closure (TAC) method affects the prognosis of trauma patients. Previous studies on TAC are challenging to extrapolate due to data heterogeneity. We aimed to conduct a systematic review and comparison of various TAC techniques.
Methods: We accessed web-based databases for studies on the clinical outcomes of TAC techniques. Recognized techniques, including negative-pressure wound therapy with or without continuous fascial traction, skin tension, meshes, Bogota bags, and Wittman patches, were classified via a method of closure such as skin-only closure *vs.* patch closure *vs.* vacuum closure; and via dynamics of treatment like static therapy (ST) *vs.* dynamic therapy (DT). Study endpoints included in-hospital mortality, definitive fascial closure (DFC) rate, and incidence of intraabdominal complications.
Results: Among 1,065 identified studies, 37 papers comprising 2,582 trauma patients met the inclusion criteria. The vacuum closure group showed the lowest mortality (13%; 95% confidence interval [CI], 6%–19%) and a moderate DFC rate (74%; 95% CI, 67%–82%). The skin-only closure group showed the highest mortality (35%; 95% CI, 7%–63%) and the highest DFC rate (96%; 95% CI, 93%–99%). In the second group analysis, DT showed better outcomes than ST for all endpoints.
Conclusion: Vacuum closure was favorable in terms of in-hospital mortality, ventral hernia, and peritoneal abscess. Skin-only closure might be an alternative TAC method in carefully selected groups. DT may provide the best results; however, further studies are needed.
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Key Words: Abdominal injuries, Laparotomy, Negative-pressure wound therapy, Open abdomen techniques, Wound and injuries

INTRODUCTION

Open abdomen (OA) with temporary abdominal closure (TAC) is an essential component of lifesaving damage control surgery (DCS) in trauma, which is associated with high morbidity, mortality, and hospital costs [1-4]. Despite advances in trauma care, the selection of TAC is still dependent on the surgeon's experience. Under ideal conditions, TAC serves as an effective barrier in preventing evisceration, contamination, and bowel injury. Moreover, it can remove unwanted peritoneal fluid and provide easy access for reoperation. Limiting fascial retraction to achieve early definitive fascial closure (DFC) is necessary while allowing for expansion to avoid abdominal compartment syndrome (ACS). Readiness, rapidity, and cost-effectiveness are also required [1,2,5,6].

Diverse techniques have been developed for TAC, and these

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can be divided into 3 groups according to the methodology used: skin-only, patch, and vacuum closure techniques [5]. Skin-only closure is achieved by closing the skin with towel clips or sutures, leaving the fascia open. The patch closure technique comprises suturing plastic layers (such as with the use of Bogota bags, mesh [absorbable or nonabsorbable], Wittmann patches, or zippers) to the fascia or skin. Meanwhile, vacuum closure techniques include homemade or commercial negative-pressure wound therapy (NPWT) with or without continuous fascial traction (CFT). Another classification divides TAC into 2 groups depending on whether the fascia is tightened sequentially or not: static therapy (ST) and dynamic therapy (DT) [7]. CFT using dynamic retention sutures or abdominal reapproximation anchor represents DT. The Wittmann patch and mesh-mediated fascial traction can be classified as DTs, but a simple mesh fixation without mention of gradual reduction is considered an ST.

Many consensus guidelines have advocated the use of a vacuum closure as a TAC technique of choice [8-11]. As a result, vacuum closure has gained prominence, particularly with the development of industrial versions of it. However, these guidelines depend mainly on the findings of extensive and heterogeneous previous studies that have evaluated TAC. Although the concept of damage control resuscitation (DCR) has transformed the trauma resuscitation practice over the last 20 years, data collected in the pre-DCR era are a significant portion of those studies [12]. Hence, this review aimed to answer the following PICO (Population, Intervention, Comparator, Outcomes) question: in trauma patients with OA in whom emergency laparotomy has been performed, which TAC category (skin-only *vs.* patch *vs.* vacuum closure; ST *vs.* DT) should be performed to obtain better clinical outcomes in terms of mortality, DFC, and abdominal complications?

METHODS

Data sources and search

This study was conducted following the updated PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 statement [13]. The protocol for this systematic review was registered in PROSPERO, an international prospective register of systematic reviews, in 2022 (CRD42022307506) [14]. The Institutional Review Board at Dankook University Hospital exempted the study from review as we conducted a secondary analysis of published, peer-reviewed findings (No. 2022-01-021). A comprehensive search was conducted from the date of database inception to June 2022 using standard web-based databases, including PubMed, Embase, the Cochrane Central Register of Controlled Trials, and Clinicaltrials.gov. The search terms are presented in Supplementary Fig. 1.

Study selection

We included published studies that met the following criteria: (1) study design: randomized controlled trials (RCTs), cohort studies, or case series; (2) study population: trauma patients only; and (3) results: including at least one of the aforementioned endpoints of interest. The exclusion criteria were: (1) studies on nontrauma or pediatric patients; (2) studies with inappropriate data (i.e., data not categorized by the TAC method); (3) case series and reports including <5 cases; (4) reviews, meta-analyses, study protocols, conference abstracts, letters, editorials, commentaries, and *in vivo* or *in vitro* research (i.e., research on animals or cell lines, respectively); and (5) non-English publications (except for including articles with English abstract). No restrictions were placed on indications for OA. The study selection process was conducted independently by the 2 study authors and any disputes were resolved by consensus.

Data extraction and definitions

The 2 study authors collected the data independently. The extracted data included primarily basic information, such as the first author and year of publication, baseline study characteristics (including sample size, mean or median values for age, and the Injury Severity Score [ISS] for each group), and clinical endpoints. These endpoints included in-hospital mortality, DFC rates, and the incidence of 3 abdominal complications (enteric fistula [EF], ventral hernia [VH], and peritoneal abscess [PA]) by the TAC group. DFC was defined as the attainment of complete midline fascial closure without prosthesis, regardless of the number of days necessary for this to occur. EF includes both enterocutaneous and enteroatmospheric fistulas. Any mention of unplanned protrusion of the peritoneal contents between the fascia following DFC was considered VH. If the outcomes of interest were not mentioned in the published studies, they were considered unavailable. Recognized TAC techniques (NPWT with or without CFT, skin tension, meshes, Bogota bags, Wittman patches) were classified as skin-only *vs.* patch *vs.* vacuum closures and ST *vs.* DT. The descriptions, strengths, and drawbacks of each TAC technique (according to a comprehensive review of the literature) are summarized in Table 1.

Data synthesis and analysis

All the analyses were performed using the meta-analysis module in R (ver. 5.1-1; The R Project for Statistical Computing) [15]. Forest plots were created to display the results of the data synthesis visually (Supplementary Figs. 2–6). Weighted proportions and 95% confidence intervals (CIs) were generated for comparisons of each TAC category. If there was a statistically high heterogeneity ($I^2 \geq 50\%$) among the study results for a given outcome, the random-effects model was used as a reference; otherwise ($I^2 < 50\%$), a fixed-effects model was used.

Table 1. Summarized strengths and drawbacks of each TAC technique

Category	TAC technique	Definition/description	Strengths	Drawbacks
Skin-only closure	Towel clip	Skin is closed over the opened fascia with series of towel clips	Rapid, cheap, and easily available. Minimizes fluid and heat losses	Risk of skin injury and infection. High incidence of abdominal compartment syndrome and evisceration. Interference with radiographs
	Suture	A monofilament running suture to skin remains in discontinuity		
Patch closure	Absorbable mesh	An absorbable mesh is fixed between the fascial edges. Intended to make a granulation for future skin graft. Can be left *in situ* permanently (e.g., polyglycolic acid [Dexon, Davis & Geck], polyglactin 910 [Vicryl, Ethicon], Gore Bio-A mesh)	Obviate lateral retraction of the fascia. Allow less traumatic access into the peritoneal cavity for reoperation, because not unravel when cut and close	Contractures of wound, hernia, enteric fistula (especially absorbable mesh), and mesh extrusion are common. Abdominal wall laxity more akin to planned ventral herniation. Increased risk of infection in microporous meshes. Tear at the suture site in case of an absorbable mesh
	Nonabsorbable mesh	Loose suture of permanent synthetic meshes to the fascial edges, then gradual fascial approximation by excision and resuture (e.g., polypropylene mesh, polytetrafluoroethylene mesh)		
	Bogota Bag	Sterile plastic bag (i.e., 3-L irrigation bag) is sutured between the wound edges (fascia or skin)	Cheap, readily available, and easy to use. Visual inspection of the peritoneal cavity allowed. Minimize body heat and fluid loss. Nonirritating to the viscera	Not preventing loss of domain. Easy evisceration at the edge. Not allowed fluid removal
	Wittmann patch	Two opposite synthetic sheets with hooks/loops (Velcro) are sutured to allow fascial tension. Also known as the 'artificial burr' (e.g., Wittman Patch [Starsurgical, Inc.])	Sequential approximation at the bedside without general anesthesia. Easy abdominal reentry	Expensive (USD 1,440.00 per patient)
Vacuum closure	Homemade negative-pressure wound therapy	Perforated plastic sheets cover the bowel, either towels or sponges are placed on top, and finally airtight sealing connected to a suction drain (e.g., Barker's vacuum pack technique, institution-specific technique)	Removal of exudates and inflammatory mediators. Improvement of blood supply, angiogenesis, and neutrophil chemotaxis. Decreases bacterial proliferation	High incidence of enterocutaneous fistula if viscera is not covered properly. Inconsistent outcomes unless commercial products are available
	Commercial negative-pressure wound therapy	Industrial versions with prepacked and standardized systems are available with a special drainage tube that can be connected to a negative-pressure pump (e.g., Abthera Open abdomen negative-pressure therapy system [KCI, Acelity Company])		
	Continuous fascial traction	Large sutures, vessel loops, elastomers, or interposition mesh placed through the whole abdominal wall to aid in fascial approximation	Highest fascial closure rate when used with vacuum closure	Some materials may not be available in rural region

TAC, temporary abdominal closure.

Table 2. Demographic and clinical characteristics of the included studies

Category	TAC technique	Study	Year	No. of patients	Mean age (yr)	Mean ISS	Definitive fascial closure (%)	In-hospital mortality (%)	Intraabdominal complications (%)			Quality[a)]
									Fistula	Hernia	Abscess	
Skin-only closure	Towel clip	Smith et al. [21]	1992	8	31.1	32.4	75	37.5	0.0	0.0	0.0	3
		Offner et al. [22]	2001	25	NA	NA	NA	32.0	NA	NA	NA	5
	Suture	Hu et al. [23]	2018	138	37.9	25.1	96.4	3.6	2.9	5.8	32.6	5
	Both	Burch et al. [20]	1992	189	NA	NA	NA	67.7	0.0	1.1	0.0	5
Patch closure	Absorbable mesh	Mayberry et al. [24]	2004	140	35.8	31.2	31.4	17.1	7.1	67.1	5.0	6
	Nonabsorbable mesh	Cohn et al. [25]	1995	14	NA	NA	64.3	28.6	NA	NA	NA	3
		Yeh et al. [26]	1996	36	33.0	NA	22.2	27.8	NA	NA	NA	3
		Vertrees et al. [27]	2006	29	27.0	33.1	82.8	0.0	0.0	3.5	3.5	4
		Vertrees et al. [28]	2008	83	26.0	30.0	85.5	2.4	2.4	4.8	25.3	5
	Mixed mesh[b)]	Nagy et al. [29]	1996	25	30.7	20.3	40.0	32.0	12.0	12.0	0.0	3
	Bogota Bag	Burch et al. [20]	1992	10	NA	NA	NA	50.0	NA	NA	NA	5
		Fernandez et al. [30]	1996	15	48.1	36.1	NA	60.0	NA	NA	NA	3
		Offner et al. [22]	2001	17	NA	NA	NA	24.0	NA	NA	NA	5
		Sánchez-Lozada et al. [31]	2004	12	36.0	25.0	NA	25.0	33.0	33.0	25.0	3
		Weinberg et al. [32]	2008	7	NA	NA	14.3	NA	0.0	0.0	0.0	5
		Hsu et al. [49]	2018	64	35.8	31.7	82.8	26.6	NA	NA	NA	4
		Hu et al. [23]	2018	60	36.3	24.8	83.3	15.0	10.0	6.7	40.0	5
	Wittmann patch	Aprahamian et al. [50]	1990	20	29.5[d)]	30.5[d)]	75.0	20.0	0.0	10.0	15.0	4
		Hadeed et al. [33]	2007	26	NA	NA	76.9	7.7	3.9	0.0	0.0	4
		Weinberg et al. [32]	2008	36	37.0	34.0[d)]	77.8	0.0	0.0	2.8	0.0	5
		Smith et al. [34]	2010	8	30.4	34.0	87.5	NA	NA	NA	NA	6

Table 2. Continued

Category	TAC technique	Study	Year	No. of patients	Mean age (yr)	Mean ISS	Definitive fascial closure (%)	In-hospital mortality (%)	Intraabdominal complications (%)			Quality[a]
									Fistula	Hernia	Abscess	
Vacuum closure	Homemade NPWT	Barker et al. [35]	2000	112	38.9	27.5	55.4	25.9	4.5	0.0	4.5	4
		Johnson et al. [36]	2001	21	25.6	30.4	66.7	9.5	9.5	0.0	14.3	5
		Chavarria-Aguilar et al. [37]	2004	29	42.5	23.2	75.9	10.3	0.0	0.0	20.7	5
		Diaz et al. [46]	2004	75	35.0	50.6	NA	49.3	6.7	NA	4.0	4
		Jiang et al. [54]	2006	13	NA	NA	53.8	NA	0.0	NA	23.1	4
		Smith et al. [34]	2010	19	30.9	36.0	94.7	10.5	0.0	5.3	0.0	6
		Kirkpatrick et al. [19]	2015	22	56.0[d]	34.0[d]	54.5	NA	4.6	NA	NA	High
		Smith et al. [18]	2017	103	32.0	28.3	74.8	NA	1.9	NA	1.9	High
	Commercial NPWT	Garner et al. [38]	2001	14	40.1	24.4	92.8	0.0	0.0	7.1	0.0	3
		Suliburk et al. [39]	2003	29	38.0	26.0	72.4	0.0	6.9	0.0	0.0	3
		Miller et al. [51]	2004	45	36.0	34.0	84.4	0.0	2.2	2.2	0.0	4
		Stone et al. [40]	2004	48	NA	25.0	54.2	33.3	4.2	0.0	10.4	3
		Labler et al. [41]	2005	18	35.1	41.1	77.8	27.8	0.0	0.0	11.1	4
		Weinberg et al. [32]	2008	9	NA	NA	66.7	NA	0.0	0.0	0.0	5
		Ott et al. [42]	2011	79	37.1	21.0[d]	NA	10.1	NA	NA	NA	5
		Burlew et al. [43]	2012	22	33.1	35.6	54.6	4.6	13.6	0.0	36.4	5
		Navsaria et al. [52]	2013	20	31.4	25.0[d]	65.0	20.0	5.0	0.0	0.0	4
		Harvin et al. [47]	2013	77	NA	NA	79.2	NA	NA	NA	NA	5
		Kirkpatrick et al. [19]	2015	23	56.0[d]	23.0[d]	69.6	NA	8.7	NA	NA	High
		Wang et al. [45]	2019	36	37.0	36.0[d]	27.8	NA	13.9	0.0	0.0	5
	Mixed NPWT[c]	Dubose et al. [53]	2013	572	39.1	28.2	65.4	14.9	5.2	0.0	19.7	5
		Hu et al. [23]	2018	41	41.7	28.7	92.7	12.2	4.9	0.0	29.3	5
		Edwards et al. [48]	2022	120	41.9	24.7	78.3	10.0	10.0	6.7	26.7	5
	Commercial NPWT + CFT	Burlew et al. [43]	2012	29	35.4	38.2	100.0	3.5	0.0	3.5	31.0	5
		Dennis et al. [44]	2013	32	29.5	19.1	100.0	0.0	12.5	0.0	0.0	4
		Wang et al. [45]	2019	12	25.0	29.0[d]	100.0	NA	0.0	0.0	0.0	5

TAC, temporary abdominal closure; ISS, Injury Severity Score; NA, not available; NPWT, negative-pressure wound therapy; CFT, continuous fascial traction.
[a]Quality assessment using the Newcastle-Ottawa scale (out of 9 points) or Cochrane risk of bias tool for randomized trials (low risk or some concerns or high risk). [b]Absorbable and nonabsorbable meshes. [c]Both homemade and commercial NPWT, or not mentioned. [d]Median values.

The 2 authors independently evaluated the methodological quality of RCTs and non-RCTs using a revised Cochrane risk of bias tool for randomized trials (RoB 2) and the Newcastle-Ottawa scale (NOS), respectively [16,17].

RESULTS

Characteristics of the included studies

A total of 1,065 relevant publications were identified during our initial literature search. Of these, 2 randomized controlled studies [18,19], 29 retrospective observational studies [20–48], and 6 prospective observational studies [49-54] that were published between 1990 and 2022 met the inclusion criteria; these studies included a total of 2,582 patients (Table 2). The study selection process is depicted in Fig. 1.

According to RoB 2, the risk of bias of the included RCTs was judged as either 'low risk,' 'some concerns,' or 'high risk.' Using the NOS, the quality of the included observational studies ranged from 3 to 6 stars. Although all the studies evaluated post-trauma patients, we identified various indications for TAC, including post-DCS, primary and secondary ACS, peritonitis, planned reoperation, necrotizing fasciitis, necrotizing pancreatitis, and abdominal wall defects. Vacuum closure was the most common TAC category used in 1,620 patients (73.3%, 23 studies) [18,19,23,32,34-48,51-54] followed by patch closure in 602 patients (27.3%, 16 studies) [20,22-34,49,50] and skin-only closure in 360 patients (16.3%, 4 studies) [20-23]. DT was used in 163 patients (6.3%, 7 studies) [32-34,43-45,50], whereas the rest used ST.

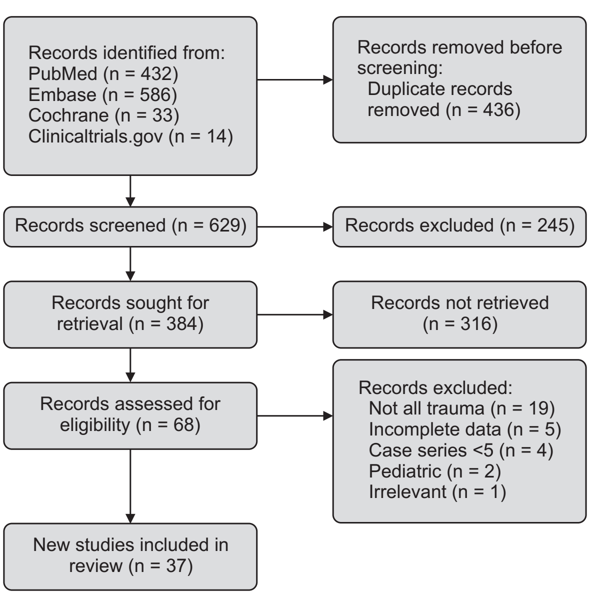

Fig. 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 flow diagram.

Meta-analysis results

In-hospital mortality

A total of 31 studies presented in-hospital mortality rates [20-31,33-44,46,48-53]. The lowest weighted in-hospital mortality rate was observed with the use of vacuum closure (13%; 95% CI, 6%–19%), whereas the highest rates were seen within the skin-only category (35%; 95% CI, 7%–68%) (Table 3). In the second group analysis, DT was superior to ST (1% [95% CI, 0%–4%] *vs.* 20% [95% CI, 14%–26%]).

Definitive fascial closure rates

Overall, 31 studies reported DFC rates [18,19,21,23-29,32-41,43-45,47-54]. The highest weighted rate was observed in the skin-only group (96%; 95% CI, 93%–99%), whereas the lowest weighted rate was observed in the patch closure group (64%; 95% CI, 50%–78%) (Table 4). In the second group analysis, DT was superior to ST again (90% [95% CI, 47%–100%] *vs.* 68% [95% CI, 60%–75%]).

Table 3. Weighted proportions for in-hospital mortality by TAC technique category

TAC category	No. of studies	No. of patients	In-hospital mortality			
			%	95% CI	I^2 (%)	P-value
Methodology						
Skin-only closure	4	360	35	7–63	99	<0.01
Patch closure	15	587	19	11–27	87	<0.01
Vacuum closure	18	1,325	13	6–19	90	<0.01
Dynamics						
Static therapy	28	2,129	20	14–26	94	<0.01
Dynamic therapy	5	143	1[a]	0–4	44	0.13

TAC, temporary abdominal closure; CI, confidence interval.
[a]Fixed effects (I^2 < 50%).

Table 4. Weighted proportions for definitive fascial closure rate by TAC technique category

TAC category	No. of studies	No. of patients	Definitive fascial closure			
			%	95% CI	I^2 (%)	P-value
Methodology						
Skin-only closure	2	146	96[a]	93–99	48	0.16
Patch closure	13	548	64	50–78	94	<0.01
Vacuum closure	24	1,466	74	67–82	94	<0.01
Dynamics						
Static therapy	28	1,997	68	60–75	94	<0.01
Dynamic therapy	7	163	90	47–100	74	<0.01

TAC, temporary abdominal closure; CI, confidence interval.
[a]Fixed effects (I^2 < 50%).

Table 5. Weighted proportions for enteric fistula by TAC technique category

TAC category	No. of studies	No. of patients	Enteric fistula			
			%	95% CI	I^2 (%)	P-value
Methodology						
Skin-only closure	1	138	2	NA	NA	NA
Patch closure	7	375	5	2–9	58	0.02
Vacuum closure	22	1,436	4[a)]	3–5	25	0.14
Dynamics						
Static therapy	23	1,850	4[a)]	3–5	33	0.05
Dynamic therapy	4	99	2[a)]	0–5	31	0.23

TAC, temporary abdominal closure; CI, confidence interval; NA, not available.
[a)]Fixed effects used (I^2 < 50%).

Table 6. Weighted proportions for ventral hernia by TAC technique category

TAC category	No. of studies	No. of patients	Ventral hernia			
			%	95% CI	I^2 (%)	P-value
Methodology						
Skin-only closure	3	335	3	0–7	60	0.08
Patch closure	8	405	16	1–32	97	<0.01
Vacuum closure	7	281	3[a)]	1–5	3	0.40
Dynamics						
Static therapy	13	904	10	1–20	95	<0.01
Dynamic therapy	4	117	2[a)]	0–5	0	0.46

TAC, temporary abdominal closure; CI, confidence interval.
[a)]Fixed effects used (I^2 < 50%).

Table 7. Weighted proportions for peritoneal abscess by TAC technique category

TAC category	No. of studies	No. of patients	Peritoneal abscess			
			%	95% CI	I^2 (%)	P-value
Methodology						
Skin-only closure	2	146	17	0–49	93	<0.01
Patch closure	6	344	18	6–30	89	<0.01
Vacuum closure	16	1,309	13	7–18	91	<0.01
Dynamics						
Static therapy	21	1,718	15	9–20	92	<0.01
Dynamic therapy	3	81	14	0–32	87	<0.01

TAC, temporary abdominal closure; CI, confidence interval.

Intraabdominal complications

A total of 29 studies evaluated intraabdominal complications [18,19,21,23,24,27-29,31-41,43-46,48,50-54]. Patch closure showed the highest weighted incidences of EF (5%; 95% CI, 2%–9%), VH (16%; 95% CI, 1%–32%), and PA (18%; 95% CI, 6%–30%) (Tables 5–7). In the second group analysis, DT was superior to ST in EF (2% [95% CI, 0%–5%] *vs.* 4% [95% CI, 3%–5%]), VH (2% [95% CI, 0%–5%] *vs.* 10% [95% CI, 1%–20%]), and PA (14% [95% CI, 0%–23%] *vs.* 15% [95% CI, 9%–20%]).

DISCUSSION

Apposition of the fascia without concern for ACS is the final goal of OA management. DFC failure is anticipated when OA persists beyond 5–8 days or following a third reexploration [6,55]. The longer the OA persists, the higher the risk of infectious complications because of repeated dressing changes. Among the patients with OA, 25% developed EF, PA, or wound infections; a greater tendency to develop these complications was observed after 8 days [56,57]. Moreover, the achievement of DFC beyond 5 days was 4–16.8 times more likely to induce anastomotic leakage [58,59]. Once in this downward spiral of abdominal infections hampering DFC, other systemic infections (such as bacteremia or pneumonia) may also arise. Failed DFC increased bloodstream infections (18.4% *vs.* 6.5%), thereby emphasizing the need to accomplish DFC rapidly when permitted by the patient's physiology [53].

If DFC cannot be achieved within 8 days, the current trend advocates the initiation of DT [7,60]. Numerous reports have demonstrated that NPWT with CFT yields better results than NPWT alone, although most study participants evaluated in these prior studies were non-trauma patients [2,61,62]. Accordingly, the World Society of Emergency Surgery and the Eastern Association for the Surgery of Trauma (EAST) recommended NPWT with CFT as the primary technique for TAC [8,63]. In another meta-analysis and guideline, the EAST recommended that CFT should be used over routine care in the management of OA after DCS [63]. However, the recommendation was limited to hemodynamically stable patients. The increase in the dynamics of TAC is in concordance with the results of the present meta-analysis, where DT showed better outcomes than ST at all endpoints. Nevertheless, these results should be interpreted carefully given the small number of studies that were included in this analysis. Additional protocol-based data using DT are needed to validate the positive findings.

Historically, high mortality of skin-only closure has been attributed to its innate feature of promoting ACS [57,64,65]. ACS is associated with worse outcomes, including increased ventilator days, longer intensive care unit stay, and multi-organ failure [65]. According to our analysis, skin-only closure was significantly more likely to result in DFC than vacuum closure. However, caution is needed in the interpretation, as patients treated with a skin-only technique in the recent cohort have been found to experience less injury burden (selection bias) [23]. In the era of DCR, resuscitation strategies focus on the limitation of visceral edema. Therefore, skin-only closure might be an alternative in selected patients who are less likely to develop ACS (i.e., not require massive volume resuscitation), especially in rural areas where NPWT is unavailable [66]. Further studies are required to confirm whether strict compliance with DCR prevents ACS under the skin sutures.

Our study had some limitations mainly due to data heterogeneity. First, the mean age and ISS of the patients could not be calculated across all the included studies as well as in each category because some of the values were presented as medians. Second, the individual study-level inclusion and exclusion criteria differed markedly between the included studies. Moreover, the indications for OA after trauma were not uniform. DCS was the primary indication for OA with TAC in 22 of 37 (59.5%) studies [18,20-23,25,28,30,32-34,36,39,41,45,47-49,52,53], with mixed indications reported in another 11 studies [19,24,27,35,37,38,40,46,50,51,54]. Only 1 study reported severe peritonitis after trauma [31]. Two studies did not mention the indication for OA [26,29]. In addition, 17 studies excluded patients with early mortality (i.e., intraoperative mortality, 24/48/72-hour mortality, and mortality before fascial closure) as this would have diminished the calculated in-hospital mortality rate [18,20,22,24,33,34,37,39,42-45,47,49-51,53]. Third, other confounding factors (i.e., time to closure, variations in practice protocols, evolution of DCR, and reliability of critical care support) affecting permanent closure could not be controlled. The surgeon's personal preferences in choosing a specific TAC method may likewise have introduced a selection bias into each cohort. Fourth, only 10 studies reported the duration of the study follow-up period [19,21,24,32,34,41,43,44,48,52], which may have impacted the accuracy of the VH incidence findings; this is because VH is usually a long-term complication of OA. The overall poor methodological quality of the available evidence was another limitation of this investigation. Most of the included studies were retrospective investigations. Inherent difficulties in conducting RCTs in trauma centers may explain this finding. Statistical methods to evaluate publication bias were not conducted, as they are not suitable for proportional meta-analysis [67]. Thus, small-study effects must be considered when interpreting our data. Future evaluations with well-designed, high-quality, and highly powered RCTs are warranted to provide more uniform and gold-standard recommendations. Despite these limitations, we provided a roadmap for the optimized selection of TAC methods for trauma surgeons. To the best of our knowledge, this is the first meta-analysis on the use of TAC, including studies performed purely within populations of trauma patients (both hemodynamically stable and unstable patients).

In conclusion, the vacuum closure may have advantages in terms of in-hospital mortality, VH, and PA. The utilization of the skin-only technique should be restricted, considering the potential risk of ACS. Although these study results have highlighted the importance of DT over ST, the potential limitations of data heterogeneity should be considered. Future investigations balancing various confounding variables are required to achieve a more comprehensive understanding of the best TAC technique for the management of OA in trauma patients.

SUPPLEMENTARY MATERIALS

Supplementary Figs. 1–6 can be found via https://doi.org/10.4174/astr.2023.104.4.237.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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