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Vacuum-assisted closure device in the postoperative wound care for Fournier's gangrene: a systematic review

Daniela Franco-Buenaventura[1,2] · **Herney Andrés García-Perdomo**[1,2]

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Abstract

Purpose To determine the effectiveness of Vacuum-Assisted Closure Device in the postoperative wound care for Fournier's gangrene

Methods We performed a systematic review in the following databases: Medline (Ovid), EMBASE, and The Cochrane Central Register of Controlled Trials (CENTRAL), from inception to nowadays. We included RCTs and analytical observational studies. Meta-analysis was not possible given the clinical and methodological heterogeneity of the studies.

Results We included six studies that compared VAC treated patients and a control group. The length of stay of the VAC treated vs. the conventional dressing treated patients was higher for the VAC treated patients in all but one of the included studies. The VAC group had the highest number of surgical debridements requiring anesthesia. The conventionally treated patients had a higher number of daily dressings, and the need for additional dressing changes, without anesthesia. Two studies found significantly higher mean scores for VAS, requiring a higher need for daily analgesics for the control group patients.

Conclusions VAC therapy is an effective method, but it is not better than conventional dressing treatment. VAC carries fewer dressing changes, less pain, and less need for analgesics, but it comes with a higher need for surgical interventions requiring anesthesia.

Keywords Fournier gangrene · Negative-pressure wound therapy · Vacuum-assisted closure

Introduction

Fournier's gangrene (FG) is a rare condition first described in 1883 [1]. It is defined as a necrotizing infection that initially affects the perineal region and rapidly spreads along with the fascial layers to external genitals, perianal, and even abdominal zones. The etiology can be divided into urogenital, anorectal, and cutaneous sources. The most frequently affected patients are diabetic, alcoholic, and immunocompromised male patients [2, 3].

The three main principles accepted for the management of Fournier's Gangrene are initial resuscitation, empirical broad-spectrum antibiotic coverage for Gram-positive, Gram-negative, and anaerobic microorganisms, and early aggressive surgical intervention [3, 4]. To accomplish that, the affected patients need a multidisciplinary management at an intermediate or intensive care unit, from urologists, general surgeons, nutritionists, intensive care specialists, and phycologists. The affected patients might need one or more surgical interventions such as wide excision of dead tissues, urinary or gastrointestinal diversions (colostomy or cystostomy), and reconstructive surgeries. These patients tend to stay for long periods and represent very high costs to health systems [2].

Although Fournier's Gangrene is not a common condition, it still carries a significant morbi-mortality for affected patients [2]. Several options have been proposed in the past: namely honey, hyperbaric oxygenation, grown hormones, growing agents, and vacuum-dressing technologies; however, most of them are not effective for wound closure.

The Vacuum-Assisted Closure System (VAC) is a wound care system that creates a continuous negative pressure at the surgical site [2]. It seals the wounds with a polyurethane foam sponge and an adhesive, connected to a negative pressure pump. It can be repositioned every 48–72 h [1, 2]. This

✉ Herney Andrés García-Perdomo
herney.garcia@correounivalle.edu.co

[1] Department of Surgery/Urology, School of Medicine, Universidad del Valle, Cali, Colombia

[2] UROGIV Research Group, Universidad del Valle, Cll 4B, #36-00 Cali, Colombia

technology has been widely studied for reconstructive purposes: it increases wound vascularization, fibroblast migration, and cell proliferation. These characteristics help for a faster-scaring process, even for complex infected wounds [1, 2]. Following the same mechanism, it also augments the available oxygen, and so it affects the anaerobic bacteria environment, favoring the control of infection [3].

The surgical excision has to be extensive and aggressive for a patient affected by Fournier's Gangrene. Such an extensive wound represents a challenge for nurses, doctors, and finally, surgeons, in charge of the curing interventions and reconstructive surgeries [3]. By increasing the vascular supply and available oxygen, reducing the scaring time, and controlling the infection of even complex wounds, the VAC technology is an efficient and secure therapeutic option for the postoperative wounds of Fournier's Gangrene patients [2]. Some data suggests that the VAC reduces the number of required surgical and curing interventions – for instance, until the granulation tissue is enough for proceeding to the grafting of the wound is ready for a flap coverage-; it also helps with the scaring process after the reconstructive procedure. Besides that, other authors also affirm that the VAC System diminishes the number of analgesics, sedative substances, hospital stay, and, finally, improves the patients' quality of life [2]. That so, our study aims to determine the effectiveness of Vacuum-Assisted Closure Device in the postoperative wound care for Fournier's gangrene.

Methods

We conducted this study according to Cochrane's recommendations and the PRISMA statement.

Eligibility criteria

Study designs

We included analytical observational studies. We could not find any clinical trial.

Participants

Studies including patients with Fournier's Necrosis who received VAC therapy compared with conventional therapy.

Intervention

Vacuum-Assisted Closure Device.

Comparison

Conventional therapy.

Outcomes

Length of hospital stay, UCI stay duration, mortality, number of surgical debridement and daily dressings, time from initial surgical debridement to wound closure, type of wound closure, costs, pain (analgesic need, Visual Analog Scale).

Timing

None defined.

Search methods

We conducted a search strategy in MEDLINE (OVID), EMBASE, and the Central Cochrane Controlled Trials Register (CENTRAL) from its inception to nowadays (Appendix 1). We saturated information searching in google scholar, thesis databases, registries of clinical trials, and conferences. There was no language restriction.

Collection of data

We examined the references obtained from databases on a title/abstract level and then, if potentially relevant, retrieved as complete articles. After the title/abstract phase, we reviewed the full text of relevant studies for prespecified inclusion and exclusion criteria. We collected data using a standardized format, which contains the study design, participants, variables, comparisons, and results. The authors confirmed the entry of the data and verified the information for greater accuracy. Disagreements were resolved by consensus.

Risk of bias assessment

We assessed the risk of bias of the included studies through the STROBE statement.

Analysis of the data and synthesis of the results

Meta-analysis was not possible given the clinical and methodological heterogeneity presented in the studies.

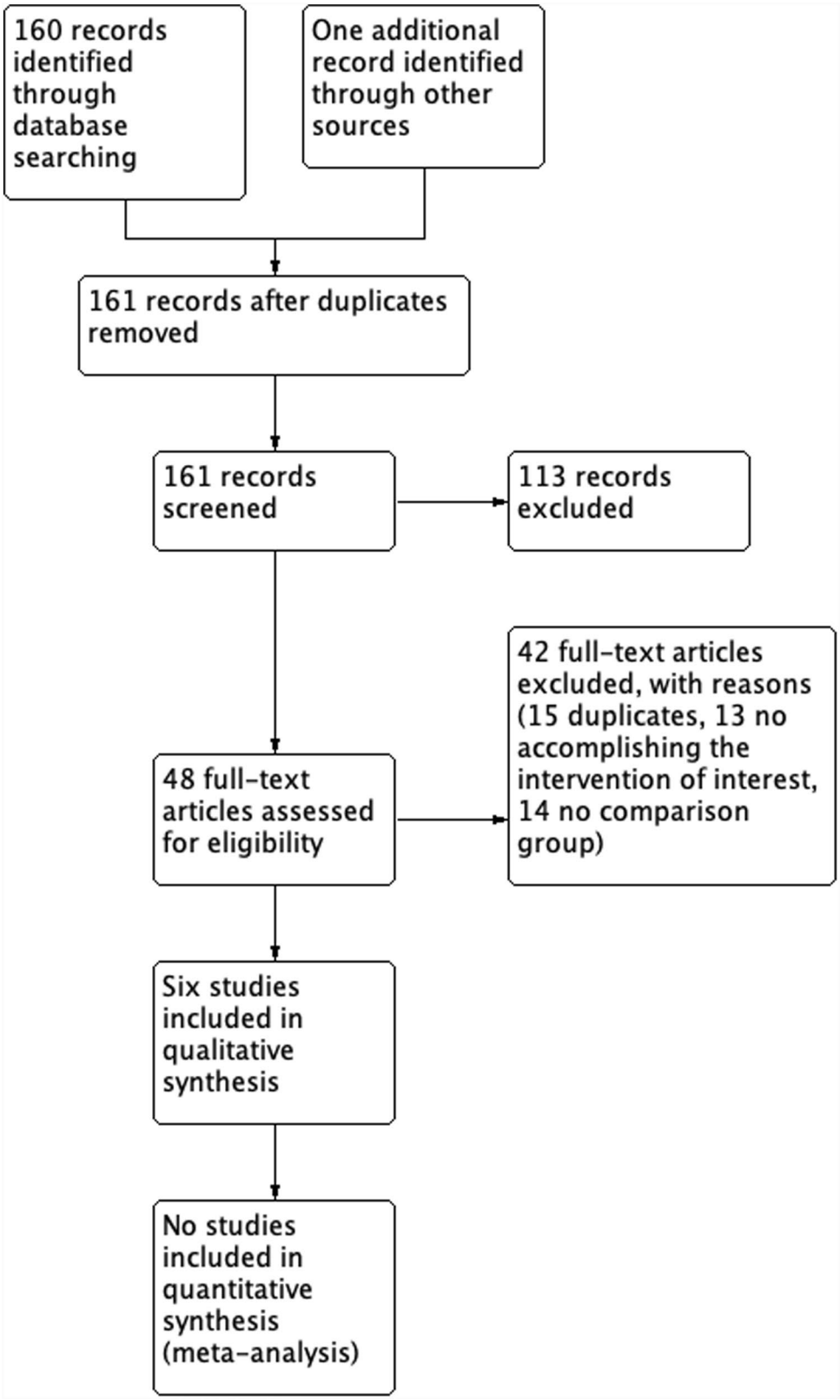

Fig. 1 Flowchart of included studies

Table 1 Characteristics of included studies

Author, Year	Study type	Patients	Control	Intervention	Closing	Antibiotics	First debridement surgery	Dressings	Colostomy	Repeated debridements	Others / patients quality of life
Ozturk et al. [5]	Observational—Analytical	10 patients	First 5 consecutive patients Initial debridement + "wet to dry" dressigns with saline. Daily changed and aditional changes if wet with epidural analgesia. Operating room every 48 h for changes, lavage, and wound exploration under sedation + epidural analgesia	Initial debridement + immediate VAC therapy (GranuFoam Large Dressing (Kinetic Concepts)). Continous suction pressure of 125 mmHg (5 min of suction—2 min of rest, until the next dressing change). Dressing change every 72 h in the operating room under sedation + epidural analgesia	Wounds clinically healed or negative wound cultures: tertiary wound closure (6 patients) or split thickness skin grafting (4 patients)	Cephtriaxon, gentamicin, metronidazol . No topical antibiotics	Immediate		Anal sphincter complex damaged: temporary laparoscopic colostomy		Pain (VAS and need for analgesia -epidural, VAS > 5-) and daily activities (# times the patient was mobile, # skipped meals anticipating general anesthesia, # aditional dressing changes at the patient request, # aditional bed sheet changes, # baths, lenght of hospital stay)
Yanaral et al. [6]	Observational—Analytical	54 patients	Initial debridement + Conventional antiseptic dressings and washed repeatedly with saline. Wound dressings were changed twice a day. Additional changes if the dressings became wet	Initial debirdement + immediate VAC therapy. Silver nitrate sponge + drape. Continuous negative pressure (initially 50 mm Hg and increased to a maximum of 125 mm Hg). Dressings were changed every 48–72 h. Additional changes if the dressings became wet	Wounds clinically healed: for small residual defects: tertiary wound closure; otherwise: skin flap or graft surgery	Third generation cephalosporin and metronidazole	During the admission day			In the case of progressive necrosis, surgical debridement was repeated.	

Table 1 (continued)

Author, Year	Study type	Patients	Control	Intervention	Closing	Antibiotics	First debridement surgery	Dressings	Colostomy	Repeated debridements	Others / patients quality of life
Yucel et al. [7]	Observational—Analytical	25 patients	Repeat debridements were performed in patients with persistent infection and necrosis after the initial debridement	In complicated cases with extensive and deep necrosis, VAC was performed together with second debridement	In healed patients, the defect was closed with primary sutures or a graft.	"Broad-spectrum antibiotics"	The patients were operated on after they were stabilized and had provided informed consent.	The tissues were irrigated with hydrogen peroxide and povidone iodine during debridement.		Repeat debridements were performed in patients with persistent infection and necrosis after the initial debridement.	
Czymek et al. [8]	Observational—Analytical	35 patients	Conventional antiseptic dressings changed once per day. Conventional dressings were used exclusively over a period of 2 years (1996 and 1997)	Both types of dressings were used in parallel over a period of 10 years (from 1998 to 2007).Three days to 5 days after primary debridement, VAC therapy was initiatied. Continuous negative pressure of 75 mm Hg was applied to the wounds and VAC dressings were changed every 48 h	"Local wound conditions had to meet the same requirements ingroups I and II before the wounds were covered with eithermeshed grafts or advancement flaps. Smallresidual defects of less than 10 cm2 did not require plasticsurgery"	"As recommended by the expert group of the PaulEhrlich Society on parenteral antibiotics"	"As soon as possible"	" Conventional antiseptic dressings impregnated with a polyhexanidesolution (polyhexanide .04%, 8.6 g NaCl, .3 gKCl, .33 g CaCl2 2 H2O, in 1,000 mL H2O). "	"If involvement of the sphincter complex or with a large-wound bed that was persistently contaminated by feces."	"In the caseof progressive necrosis, surgical debridement was repeated."	

Table 1 (continued)

Author, Year	Study type	Patients	Control	Intervention	Closing	Antibiotics	First debridement surgery	Dressings	Colostomy	Repeated debridements	Others / patients quality of life
Xu et al. [9]	Observational—Analytical	40 patients	The control group was treated by conventional debridement. The patient was given extensive debridement and induction immediately after admission, to completely remove necrotic skin, tissues and deep fascia. After multiple incisions for drainage, the incision was sutured in the second stage and placed in iodophor gauze drainage strip, and placed into a multi-sided silicone tube, with 3% hydrogen peroxide. The wound was washed with water, 0.2% metronidazole solution and saline. Gentamicin and 0.2% potassium permanganate solution was applied to the wound. Dressing were changed 1–2 times a day	The observation group was treated by vacuum-sealing drainage. Negative pressure closure Drainage technology (vacuum sealing drainage, VSD) Disposable produced by Wuhan Weiss Medical Technology Co., Ltd. Special dressing for negative pressure drainage (polyethylene alcohol, water, seaweed salt, multi-side drainage tube; Xerox Biosemipermeable film with molecular valve function produced by the company; Y connection) The Y-shaped tube was connected to the central negative pressure to adjust the negative pressure 60–80 Between kPa (125–450 mmHg), continuous negative pressure suction for 24 h. Bandages were removed 3–5 days later		Metronidazole, piperacillin, tazobactam					

Table 1 (continued)

Author, Year	Study type	Patients	Control	Intervention	Closing	Antibiotics	First debridement surgery	Dressings	Colostomy	Repeated debridements	Others / patients quality of life
Iacovelli et al. [10]	Observational—Analytical	92 patients	Conventional antiseptic dressings were used to cover the wounds (no-VAC group). As no standardized procedure has been previously described, conventional dressing depended on the single center experience. Although different antiseptic solutions were used, all the centers continued by washing repeatedly with saline until healthy granulation tissue was formed. Wound dressings were changed daily in all cases	When available in the hospital, VAC was used on the base of surgeon clinical judgement right after the surgical debridement (VAC Group). VAC was applied at 75–125 mmHg, with 5 min of suction followed by 2 min of rest, from the applica- tion until the next dressing change. For each VAC change, wounds were serially debrided under anesthesia in the oper- ating room until healthy and viable tissue was visible	Heal by secondary or tertiary (VAC-mediated) intention.	Empiric antimicrobial therapy at admission (< 12 h)	Surgical debridement (< 12 hr)	Antiseptic dressings and Hydrogen peroxide and povidone/iodine solutions	Only six patients	Surgical debridement in each VAC change. For non-VAC, only if needed	

Results

Studies selection

We identified 160 studies through the database search. After excluding duplicates, we included six studies in the qualitative analysis (Fig. 1).

Characteristics of Included studies

We included six studies in the analysis, including a control group and a VAC group [5–10](Table 1). These characteristics included: the specific management given to each of the patient groups, the antibiotic regimen, the first debridement intervention timing, the type of dressings and the frequency of changes, and the indications for new surgical interventions (debridement, urinary or intestinal diversions). On the other hand, we addressed the demographics of the included patients of each of the studies in Table 2.

There were no significant differences among groups regarding age in any of the included studies. Most of them had a higher number of men than women, except for one study, which included more women than men [7]. Most of the studies reported a high percentage of diabetic patients. There were no differences in the number of these patients among groups.

Two of the included studies reviewed the mean delay in the initiation of treatment. They reported no differences among groups. One did not report on mortality, while the other reported higher mortality for the control group, even with no differences in treatment [9].

Only one study mentioned the duration of surgery [6]. Also, two studies compared the Fournier Gangrene Severity Index (FGSI) between both groups at admission [9, 10].

Three studies reported anorectal and urogenital as the leading causes, while others reported unclear causes. Two studies reported no significant differences in etiology [5, 6]. Another study reported a higher percentage of anorectal cases [7].

Three studies reported the number of patients with gangrene confined to the perineum (local), and the ones with necrosis extended out of the pelvic region (Disseminated). Only one reported no significant difference in median wound diameter among VAC treated and conventional dressing treated patients [6].

Regarding diversions, only one study reported the need for urinary diversions, which was slightly lower for the control group [8]. Three studies reported an enterostomy need: Ozturk reported no significant differences in both groups [5]. Czymek et al. reported a significantly higher need for an enterostomy in the VAC group [8].

On the other side, two of the included studies reported a polymicrobial infection for most of the included patients [5, 8].

Characteristics of the excluded studies

The articles excluded treated different topics or had a study design that did not accomplish the inclusion criteria.

Outcomes

All of the included studies reported a comparison group. Several different outcomes were analyzed in each of the included studies. Nonetheless, we selected the ones that were most common among studies to review. We described those outcomes in Table 3.

Length of hospital and ICU stay

When comparing the length of stay of the VAC vs. the conventional dressing patients, VAC was significantly longer in two studies [7, 8]. Iacovelli et al. found a longer length of stay for patients with local and disseminated FG in the VAC group. In summary, the VAC group in all had a more extended hospital stay [10].

Only one of the included studies compared the length of stay in the Intensive Care Unit (ICU) for the VAC group vs. the conventional dressing group; they found a significantly longer stay for the VAC group [8].

Number of surgical debridements and changes of dressings

Regarding the number of surgical debridements (the ones requiring anesthesia), the VAC group had the highest number in all the studies. Nonetheless, only two found a significant difference [7, 9].

One of the studies analyzed the number of daily dressings and the need for additional dressing changes without anesthesia. They found a significantly higher for the conventionally treated patients [conventional group 2 (0–3) vs. VAC group 0, and control group 4 (3–5), vs. VAC group 2 (2–3), $p < 0.05$, respectively] [6].

Mortality

Four studies reported mortality. One of them found no significant difference among groups [6]. Another did not report the difference between groups and only had one death in the intervention group [7]. The other two studies [8, 9] reported significantly higher mortality for the control group. Of notice, most dead patients in the control group of one of these studies died on the third day of hospital stay, while the only dead patient on the VAC group died on the 51st day.

Table 2 Demographics of included studies

Study, year	Comparison Groups	*n*	Age (years)	Sex		Diabetes Mellitus, *n* (%)	Delay in initiation of treatment, median (days)	VAC duration, mean, (days)	FGSI	Origin of Fournier's Gangrene			Dissemination		Median wound diameter, cm	Urinary diversion, *n* (%)	Enterostomy needed, *n* (%)	Polymicrobiic infection
				Male, *n* (%)	Female, *n* (%)					Anorrectal, *n* (%)	Unclear	Urogenital, *n* (%)	Confined to the perineum	Extended out of the pelvic region				
Ozturk et al. [5]	Control	5	56 (31–64)	4	1		4 (3–7)			3 (60)		2	3	2			3	4
	VAC	5	56 (33–77)	3	2		5 (3–6)	10 (9–15)		3 (60)		2	2	3			3	4
Yanaral et al. [6]	Control	31	55.8 ± 14.9	31	0	13 (41.9)				13 (41.9)		18 (58.1)	31		17 (10–45)			
	VAC	23	61.6 ± 7.6	23	0	14 (60.9)				10 (43.5)		13 (56.5)	23		15 (9–44)			
	p		> 0.05			> 0.05				> 0.05					> 0.05			
Yucel et al. [7]	Control	9	53.0 ± 17.7	11 (44)	14 (56)	20 (80)				13 (52)	8 (32)	4 (16)					1	
	VAC	16	55.0 ± 13.9															
	p		0.757															
Czymek et al. [8]	Control	16	58.2 ± 13.6	9	7	4 (25)										14 (87.5)	7 (43.8)	28 (80%)
	VAC	19	57.2 ± 9.6	15	4	8 (42.1)										18 (94.7)	17 (89.5)	
	p																0 .004	
Xu et al. [9]	Control	20	46–57	20		8	(3–7)		5.6									
	VAC	20		20					5.7									
	p		> 0.05			> 0.05	> 0.05		> 0.05									
Iacovelli et al. [10]	Control	58	70 (58–82)	58	0	27			3.7	5		30	43	15		8	9	
	VAC	31	63 (54–75)	31	0	21		38–45	2–3	5		15	19	12				
	p		0.444						0.135									

Table 3 Main outcomes

Study, author	Comparison Groups	*n*	Time from initial surgical debridement to wound closure, median (days)	Number of surgical debridement	Closure		FGSI 7 d POP	FGSI 14 d POP	Lenght of stay, days	ICU stay, days	Deaths, *n* (%)
					Tertiaty, *n* (%)	Graft/flap, *n* (%)					
Ozturk et al. [5]	Control	5	9 (7–15)	3 (3–5)	3	2			13 (10–18)		
	VAC	5	10 (8–16)	3 (3–5)	3	2			14 (11–19)		
Yanaral et al. [6]	Control	31	12 (7–25)	1 (1–3)	19	10			14 (2–32)		2 (6.5)
	VAC	23	13 (11–21)	2 (1–3)	11	10			17 (4–32)		2 (8.7)
	p		> 0.05	> 0.05	> 0.05				> 0.05		> 0.05
Yucel et al. [7]	Control	9		1.7 (1-3)					12.6 (4–44)		
	VAC	16		2.8 (1–6)					26.4 (8–55)		1 (4)
	p			0.048					0.004		
Czymek et al. [8]	Control	16		4.9 (1–21)		7			27.8 ± 27.6 (1–73)	7.2 ± 8.9 (0–28)	6 (37.5) 4 at day 3
	VAC	19		10.1 (2–21)		15			96.8 ± 77.2 (39–329)	19.9 ± 18.6 (0–69)	1 (5.3) at day 51
	p								<0 .0001	0.032	0.032
Xu et al. [9]	Control	20		3.8			5.0	4.5	32 ± 2.8		4 (20.0)
	VAC	20		4.5			4.3	3.0	21 ± 1.9		0
	p			< 0.05			$p < 0.05$		< 0.05		< 0.05
Iacovelli et al. [10]	Control	58	23–56		37				18–30		13
	VAC	31	38–45		24				28–39		
	p		0.671		0.057				0.006		

Closing method

Most of the studies reported the closing method. Two of the studies comparing conventional management vs. VAC therapy found no difference among the closing method (tertiary, or graft/flap use) [5, 6]. In contrast, another found that the graft/flap use was significantly higher in the VAC group [8].

Time from initial surgical debridement to wound closure

Only two studies reported on the time from initial surgical debridement to wound closure. Two of them showed no significant difference between the control group and the VAC group [5, 6]. Iacovelli et al. found a median time longer for VAC therapy in local F ($p = 0.01$) but no difference in both groups for disseminated type ($p = 0.671$) [10].

Pain

Regarding pain, we found two studies comparing the Visual Analog Scale referred by patients receiving conventional vs. VAC therapy. Both of them found significantly higher mean scores for the patients in the control group. The first described a mean score of 6.8 [6to7] for controls, vs. 2.4 (2 to 3) for VAC treated patients. They also described a higher need for epidural analgesics for the same group [14 times (14–21) vs. four times (4–6)] [5]. The other study found a mean score of 8 (4–10) for controls, vs. 5 (4–10) for VAC treated patients ($p < 0.05$). The same study also reported a higher need for daily analgesics for control patients four times (3–5) vs. 2 (2–3), $p < 0.05$ [6].

Other outcomes

Only two studies compared the FGSI in control, and VAC treated patients at 7 and 14 days after the first debridement surgery. They found a significantly lower score in both measures for VAC treated patients [9, 10].

Ozturk 2009 reported a total cost of US$8800 in the control group and US$8850 in the VAC group, finding no differences in both groups. Also, in this study, they described the physician's opinion. They that VAC treatment was more convenient (92%), more comfortable to use (88%), and the preferred method (92%).

On the other side, Yanaral described the length of the surgical operation. They found 55 min (30–110) for the control group and 48 min (30–98) for the VAC group; no differences between groups. Also, they described that there was more frequent daily dressing (2 for the control group and 0.5 for the VAC group)($p < 0.05$).

Risk of bias assessment

We found a low risk of bias in most of the items. Nonetheless, Ozturk et al. had an unclear risk of bias regarding the variables description, statistical methods, bias management, sample size, other analysis, and funding. They did not describe information regarding those items. All studies did not show bias management, other analysis, and sample size information (Table 4).

Discussion

Because of the rapid natural progression of Fournier's Gangrene, early diagnosis and immediate aggressive, multimodality therapy with surgical debridement and broad-spectrum empiric antibiotics are crucial [11, 12]. Some data suggests that the VAC reduces the number of required surgical and curing interventions—for instance, until the granulation tissue is enough for proceeding to the wound's grafting is ready for flap coverage. It also helps with the scaring process after the reconstructive procedure. Besides that, other sources affirm that the VAC System diminishes the number of analgesics, sedative substances, the hospital stay, and at last, it improves the quality of life of the patient [2].

Previous studies report different lengths of hospitalization for patients with Fournier's Gangrene Disease, which depends on the initial clinical conditions, such as the diameter of lesions and the related complications during treatment, such as sepsis.

The VAC treatment has previously been proposed as an expediting method for wound healing [13, 14]. Tavusbay et al. reported that VAC treated wounds presented

Table 4 STROBE reporting qualiy

STROBE REPORTING QUALITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Ozturk, 2009																						
Yanaral, 2017																						
Yucel, 2017																						
Czymek, 2009																						
Xu, 2014																						
Iacovelli, 2020																						

considerable shrinking and acceleration in the granulation tissue development and reduced wound secretion [15]. It would then be thought that the length of hospitalization would be shorter for patients receiving this type of treatment [7, 16–18]. However, according to our results, the VAC system does not shorten the time from initial debridement to the wound's closing. It instead represents a more extended hospital say when compared to conventional dressing treatment.

One of the most known adverse effects associated with VAC therapy has been painful. However, the pain appears to be related to the wound's nature rather than VAC itself [19]. These patients have a higher need for anesthetic or epidural analgesia and sedation assisted procedures (for VAC system changing), which are nonpainful. Besides that, just as Ozturk et al. [5] reported previously, we found these patients to have a lower need for an in-bed change of dressings—which is a painful procedure-, compared to conventionally treated patients. This finding explains the lower pain scores and the lower need for analgesics in patients with VAC systems. It also allows for more considerable and more comfortable mobilization. It comes with a lower need for skipped meals that can be related to the effects of strong analgesics [5, 6, 17] That so, authors propose a more comfortable treatment option for patients [7].

The mortality rate associated with Fournier's Gangrene ranges from 3 to 67% and depends on various factors [8, 20]. Of notice, death is not directly related to the local tissue lesions or defects derived from surgery, but to complications associated with the disease, such as sepsis, coagulopathy, acute renal failure, diabetic ketoacidosis, or multi-organ failure [6, 21–24]. Our study found significantly higher mortality for the patients receiving conventional treatment than VAC treated ones [8]. Nonetheless, other studies showed no differences in mortality rates among the two groups.

One of the main reasons to criticize VAC therapy has been its cost [19]. Some studies affirm that the suction unit is expensive, but it can be used for a long time [5]. Philbeck et al. even determined lower costs when treating VAC patients than conventional methods [25]. Ozturk et al. [5] reported that conventional methods and VAC treatment methods showed equivalent effects in wound healing and represented similar costs. One of the included studies of our review also described almost similar costs for patients receiving conventional and VAC therapy ($8800 and $8850, respectively) [5]. Nevertheless, considering the already mentioned longer hospitalization associated with VAC therapy, one should consider these costs too before considering one option of the other as the most convenient.

The already mentioned findings, along with the effectiveness demonstrated for VAC treatment, may explain why, in some studies, it is proposed as the preferred method by physicians. One of the included studies [5] described the physicians' opinion on both options – VAC vs. conventional treatment. 50% of the physicians said that the time to change the dressings was the same for both treatments. 92% of them considered that the VAC treatment was the most convenient option, 88% said it was the easiest method to use, and 92% chose it as the preferred method.

Strengths and limitations

Most of the studies measured different outcomes, or the used measurement method was different among them. Given the clinical and methodological heterogeneity presented in the included studies, a meta-analysis was not possible.

Conclusions

According to our results, VAC therapy is an effective method, but it is not better than conventional dressing treatment. Specifically, VAC carries fewer dressing changes, less pain, and less need for analgesics, but it comes with a higher need for surgical interventions requiring anesthesia. Also, VAC therapy does not shorten the time from initial debridement to the closing of the wound. It instead represents a more extended hospital say when compared to conventional dressing treatment.

It may be a valid option, convenient for both patients and treating physicians; however, we need more well-design studies to confirm these findings.

Author contributions Research conception and design: DF-B, HAG-P. Data acquisition: DF-B, HAG-P. Statistical analysis: DF-B, HAG-P. Data analysis and interpretation: DF-B, HAG-P. Drafting of the manuscript: DF-B, HAG-P. Critical revision of the manuscript: DF-B, HAG-P. Administrative, technical, or material support: DF-B, HAG-P. Approval of the final manuscript: DF-B, HAG-P.

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Compliance with ethical standards

Conflict of interest The authors declare we had no conflict of interest and no funding.

Appendix 1 Search strategies

Medline through ovid

(Exp Fournier Gangrene or (Gangrene adj2 Fournier*).mp or (Fournier* adj2 disease).mp) AND (exp Negative-Pressure Wound Therapy or (Negative-Pressure Wound Therap*).mp or (Topical Negative-Pressure Therap*).mp or (Negative-Pressure Dressing*).mp or (Vacuum-Assisted Closure*).mp).

Central through ovid

(Exp Fournier Gangrene or (Gangrene adj2 Fournier*).mp or (Fournier* adj2 disease).mp) AND (exp Negative-Pressure Wound Therapy or (Negative-Pressure Wound Therap*).mp or (Topical Negative-Pressure Therap*).mp or (Negative-Pressure Dressing*).mp or (Vacuum-Assisted Closure*).mp).

Embase through scopus

TITLE-ABS-KEY("Fournier Gangrene" or "Fournier* disease") AND TITLE-ABS-KEY("Negative-Pressure Wound Therap*" or "Topical Negative-Pressure Therap*" or "Negative-Pressure Dressing*" or "Vacuum-Assisted Closure*").

References

1. Tucci G, Amabile D, Cadeddu F, Milito G (2009) Fournier's gangrene wound therapy: our experience using VAC device. Langenbeck's Arch Surg 394(4):759–760
2. Flores Cortés M, López Bernal F, Valera Sánchez Z, Prendes Sillero E, Pareja CF (2011) Utilización del sistema de presión negativa VAC en la gangrena perineal: Presentación de un caso. Cir Esp 89(10):682–683
3. Tiong WHC, O'Sullivan B, Ismael T (2009) Managing extensive Fournier's gangrene secondary to bilateral, inguinal hernias. J Plast Reconstr Aesthetic Surg 62(11):533–535
4. Atakan IH, Kaplan M, Kaya E, Aktoz T, Inci O (2002) A life-threatening infection: Fournier's gangrene. Int Urol Nephrol 34(3):387–92. Doi: https://doi.org/10.1023/A:1024427418743. Accessed 26 Oct 2020
5. Ozturk E, Ozguc H, Yilmazlar T (2009) The use of vacuum assisted closure therapy in the management of Fournier's gangrene. Am J Surg 197(5):660–665
6. Yanaral F, Balci C, Ozgor F, Simsek A, Onuk O, Aydin M et al (2017) Comparison of conventional dressings and vacuum-assisted closure in the wound therapy of Fournier's gangrene. Arch Ital di Urol e Androl 89(3):208–211
7. Yücel M, Özpek A, Başak F, Kılıç A, Ünal E, Yüksekdağ S et al (2017) Fournier gangreni: 25 hastanın geriye dönük analizi. Ulus Travma ve Acil Cerrahi Derg 23(5):400–404
8. Czymek R, Schmidt A, Eckmann C, Bouchard R, Wulff B, Laubert T et al (2009) Fournier's gangrene: vacuum-assisted closure versus conventional dressings. Am J Surg 197(2):168–176
9. Xu XP, Cai XH, Zhang L, Li XH, Liu ZH, Pan Y et al (2015) Clinical efficacy of vacuumsealing drainage in treatment of fournier's gangrene. World Chin J Digestol 23:348–352
10. Iacovelli V, Cipriani C, Sandri M, Filippone R, Ferracci A, Micali S et al (2020) The role of vacuum-assisted closure (VAC) therapy in the management of FOURNIER'S gangrene: a retrospective multi-institutional cohort study. World J Urol. https://doi.org/10.1007/s00345-020-03170-7
11. Wagner S, Greco F, Hoda MR, Kawan F, Heynemann H, Fornara P (2011) Is intensive multimodality therapy the best treatment for fournier gangrene? Evaluation of clinical outcome and survival rate of 41 patients. Surg Infect (Larchmt) 12(5):379–383
12. Selvi I, Aykac A, Baran O, Burlukkara S, Ozok U, Sunay MM (2019) A different perspective for morbidity related to Fournier's gangrene: which scoring system is more reliable to predict requirement of skin graft and flaps in survivors of Fournier's gangrene? Int Urol Nephrol 51(8):1303–11. Available from: https://link.springer.com/article/https://doi.org/10.1007/s11255-019-02188-0. Accessed 26 Oct 2020
13. Morykwas MJ, Argenta LC, Shelton-Brown EI et al (1997) Vacuum-Assisted Closure: a new method for wound control and treatment: animal studies and basic foundation. Ann Plast Surg 38:553–562
14. Argenta LC, Morykwas MJ (1997) Vacuum-assisted closure: a new method Surg, for wound control and treatment: clinical experience. Ann Plast 38:563–576
15. Tavusbay C, Kar H, Cin N, Kamer E, Aksut H, Karahalli O et al (2013) The use of vacuum-assisted wound closure system for management of difficult wounds. Biomed Res 24(3):329–336
16. Morpurgo EGSS (2002) Fournier's gangrene. Surg Clin North Am 82:1213–1224
17. Oguz A, Gümüs M, Turkoglu A, Bozdağ Z, Ülger BV, Agaçayak E et al (2015) Fournier's gangrene: a summary of 10 years of clinical experience. Int Surg 100(5):934–941
18. Cuccia G, Mucciardi G, Morgia G, Stagno D'Alcontres F, Galì A, Cotrufo S et al (2009) Vacuum-assisted closure for the treatment of Fournier's gangrene. Urol Int 82(4):426–431
19. Lambert KV, Hayes P, Mc Carthy M (2005) Vacuum Assisted Closure: a review of development and current applications. Eur J Vasc Endovasc Surg 29:21
20. Ersay A, Yilmaz G, Akgun YCY (2007) Factors affecting mortality of Fournier's gangrene: review of 70 patients. ANZ J Surg 77(1–2):43
21. Laor E, Palmer LS, Tolia BM et al (1995) Outcome prediction in patients with Fournier's gangrene. J Urol 154:89–92
22. Slater DN, Smith GTMK (1982) Diabetes mellitus with ketoacidosis presenting as Fournier's gangrene. R Soc Med 75:531–532
23. Lamb RC, Juler GL (1983) Fournier's gangrene of the scrotum. A poorly defined syndrome or a misnomer? Arch Surg. 118:38–40
24. Scott SD, Dawes RFH, Tate JJT et al (1988) The practical management of –20, Fournier's gangrene. Ann R Coll Surg Engl. 70:16
25. Philbeck TE Jr, Whittington KT, Millsap MH et al (1999) The clinical and cost effectiveness of externally applied negative pressure wound therapy in the treatment of wounds in home healthcare medicare patients. Ostomy Wound Manag 45:41–50