Review Article

Intrathoracic vacuum therapy for the therapy of pleural empyema—a systematic review and analysis of the literature

Björn-Ole Stüben^, Gabriel A. Plitzko, Matthias Reeh, Nathaniel Melling, Jakob R. Izbicki, Kai Bachmann[#], Michael Tachezy[#]

Department of General, Visceral and Thoracic Surgery, University Medical Centre Hamburg-Eppendorf, Hamburg, Germany

Contributions: (I) Conception and design: M Tachezy, K Bachmann; (II) Administrative support: JR Izbicki, N Melling; (III) Provision of study materials or patients: BO Stüben, GA Plitzko, M Reeh; (IV) Collection and assembly of data: BO Stüben, GA Plitzko; (V) Data analysis and interpretation: BO Stüben, M Tachezy; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Björn-Ole Stüben, MD. Department of General, Visceral and Thoracic Surgery, University Medical Centre Hamburg-Eppendorf, Martinistrasse 52, 20246 Hamburg, Germany. Email: stuebenb@me.com.

Background: Pleural empyema is a serious and potentially deadly disease leading to a significant burden on health care systems. Conservative and surgical treatment results remain poor, with high morbidity and mortality rates. Patients with pleural empyema are often multimorbid and poor candidates for surgery. Therefore, it appears sensible to explore alternative, less invasive treatment options. Recently, the well-established vacuum sponge therapy has been adopted in the treatment of pleural infections. The goal of this systematic review was to identify the existing literature and reported results of vacuum therapy for pleural empyema.

Methods: A systematic search of MEDLINE and the Cochrane Database was performed independently by two reviewers using predefined criteria according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. In addition, abstracts from selected conference proceedings were screened and reference scanning of the search results was performed. Single case reports were excluded.

Results: Fourteen studies met the selection criteria and were reviewed. A total of 165 patients were treated with vacuum therapy in the studies reviewed. 61.2% of the patients had pleural empyema secondary to thoracic surgery. In 71.5% of the patients, vacuum therapy was applied following open window thoracostomy (OWT). Mortality rates of 0–33% were reported for vacuum therapy after OWT and 0–9.3% for vacuum therapy without OWT. Length of hospital stay (LOHS) ranged from 44–217 days for patients after OWT and could not be analysed for vacuum therapy without OWT due to lacking data. Median treatment time was 7–14 days. Treatment related complications were rare overall. Success rates defined as infection resolution were high irrespective of previous treatment and cause of empyema.

Conclusions: The current literature shows that pleural vacuum therapy is a promising, safe, and feasible treatment alternative to existing treatment modalities for pleural empyema. However, the evidence for vacuum therapy without OWT is poor, and further data, optimally prospective or randomised control trials comparing the conventional surgical approach of video-assisted thoracoscopic surgery (VATS) decortication and minimally invasive vacuum therapy, are needed.

Keywords: Pleural empyema; vacuum therapy; outcomes

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^ ORCID: 0000-0001-8245-4548.

Introduction

In the last 20 years, the incidence of pleural empyema as well as mortality rates have been increasing (1-4). Treatment ranges—depending on the stage of the disease—from non-surgical interventions such as antibiotic therapy and chest tube placement to thoracoscopic or open surgery. Treatment of pleural empyema, especially chronic empyema remains a challenge with mortality rates of up to 15% having been reported (5). This explains the endeavor to explore new treatment options for this condition.

Both open surgery and video-assisted thoracoscopy (VATS) have been shown in meta-analysis to significantly reduce length of hospital stay (LOHS) in empyema patients compared to thoracostomy drainage alone (6). The goal of standard surgical therapy is the complete unleashing and decortication of the visceral pleura, enabling a re-expansion of the lung. An exception are patients with post-pneumonectomy empyema, where no lung tissue remains to fill the empyema cavity. The surgical approach is dictated by the condition of the pleural space as well as the condition of the patient. If single-lung ventilation is tolerated, VATS should be attempted according to the American Association of Thoracic Surgery consensus guidelines for stage II and II/III pleural empyema (7). It has proven benefits compared to thoracotomy in postoperative outcomes. These include improved postoperative pain control, shorter LOHS and reduction in 30-day overall mortality (8,9). VATS has now become the standard of care worldwide for the initial treatment of pleural empyema and should be attempted when possible. In reality a large number of patients need to be converted to open surgery, in patients with advanced empyema this amounts up to 46% (8).

In cases of incomplete postoperative lung re-expansion, tissue flaps may be warranted to fill the pleural cavity to prevent reformation of fluid collections. Open window thoracostomy (OWT) treatment is indicated as a rescue procedure only in patients which are unfit to undergo decortication (7), but OWT significantly impairs quality of life and leads to prolonged hospital stays (10,11). In post pneumonectomy patients, OWT may also impair the re-expansion of the contralateral side and lead to worsening right heart failure.

Vacuum sponge therapy was introduced over 30 years ago, and there is hardly any chronic or difficult wound where application has not at least been tried. It reduces edema, promotes bacterial clearance and increases perfusion to the wound bed (12). Intrathoracic vacuum therapy is a relatively new treatment option for pleural empyema. Vacuum sponge treatment of pleural empyema might have potential benefits: (I) the suction therapy induces a softening of the empyema membrane and thereby enables a collapse of the cavity. Hence, complete decortication may not be necessary. Due to the negative pressure established in the thoracic cavity, the diaphragm is elevated and may facilitate closure of relevant tissue defects. (II) The healthy parts of the lung could potentially be left untouched. With less aggressive decortication and spreading of the infectious material, surgically induced aggravation of septic conditions or even a septic shock might be reduced. (III) Additionally, bleeding and air-leak complications often seen in patients having received surgical treatment might be reduced by this approach (D). Due to the pre-existing empyema-sac, a single lung ventilation might not be necessary, reducing patient burden and simplifying the anaesthesiologic procedure.

The aim of the current manuscript is a systematic review of the current literature of intrathoracic vacuum therapy for pleural empyema and to discuss its potential drawbacks and benefits in comparison with the conventional surgical approach. The review also aims to highlight where additional research needs to be carried out and what benefits this may have for patients being treated for pleural empyema. We present the following article in accordance

Highlight box

Key findings

- Intrathoracic vacuum therapy is a safe treatment option for patients with pleural empyema.
- Vacuum sponge therapy adds a treatment option to otherwise inoperable, critically ill patients.
- Vacuum therapy has the potential to become a primary treatment alternative for pleural empyema stage II and III.

What is known and what is new?

- Intrathoracic vacuum therapy is currently used mostly for volume reduction in patients with OWT.
- Recently, vacuum therapy has been technically adapted to allow minimally invasive approaches to apply this treatment to pleural empyema cavities without the need for OWT creation and rib resection.

What is the implication, and what should change now?

- More data and larger scaled analyses are needed to further validate the potential of thoracic vacuum therapy in pleural empyema.
- Randomised prospective trials are needed to evaluate vacuum therapy as a primary treatment option for empyema.

with the PRISMA reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1188/rc).

Methods

Inclusion criteria

We searched for prospective and retrospective studies describing vacuum therapy for pleural empyema, regardless of country of origin.

Exclusion criteria

Single case reports were excluded from the analysis.

Quality of included studies

We performed ROBINS-I scoring to evaluate the risk of bias in the included retrospective studies (13). The overall risk of bias of the retrospective studies was low to moderate in twelve studies, but two studies showed a serious risk of bias, mainly due to missing data. No testing for publication bias for the primary outcome was performed as recommended by the Cochrane Collaboration due to the small number of studies and patients.

Outcomes

The primary analysed outcome was the rate of successful healing of pleural empyema. This outcome was heterogeneously defined in the studies analysed, ranging from reduced systemic signs of infection and negative cultures (14) to 50% reduction in empyema cavity and reduced infectious signs (15), to clean cavity and ability to perform thoracic closure (16,17). The other studies did not have clearly defined success surrogates. Secondary outcomes were mortality, hospitalisation time (in days), complications, median duration of therapy (in days), and number of interventions.

Search strategy

We performed a systematic review according the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) checklist (18) searching for published and unpublished trials in German and English using the Cochrane central register of controlled trials and MEDLINE (1 January 2008 to 1 August 2022). Searches were carried out using medical subject headings and free-text words.

A MEDLINE (Ovid interface) was performed during August 2022. The search terms applied are listed in *Table 1*. We combined the MEDLINE search strategy with the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE. In addition, we searched the reference lists of articles retrieved by the search and contacted experts in the field to obtain additional data. We also searched relevant journals and conference abstracts to address the issue of publication bias.

Data collection and analysis

The titles and abstracts of the manuscripts were independently assessed by two investigators (MT and BOS). Studies that clearly did not meet the inclusion criteria were excluded. The full texts of all possibly relevant articles were evaluated to determine eligibility. Disagreements were resolved by consultation with a third investigator (KB).

Independently, the following data were retrieved: authors, year of publication, country, inclusion and exclusion criteria, study methodology, number of treated patients, age and sex of patients, underlying cause of empyema, method of vacuum sponge application (thoracotomy/VATS, OWT), duration of treatment, number of interventions, outcomes including treatment-related complications, healing rate, overall LOHS, length of postoperative stay (LOPS), in-hospital mortality and possible ambulatory treatment and time to ambulatory treatment.

Study quality

Risk of bias was evaluated by the two investigators based on the ROBINS-I score, validating each grade of confounding, selection, classification of and deviation from intervention, missing data, outcome measurement, and selection of reported results (13). Disagreements were objectively discussed by the two investigators until an agreement was reached.

Quality of evidence

The quality of the evidence was poor overall. The main limitations were few included studies for analysis, inconsistencies among studies and only retrospective case series with poor standardisation and limited patient numbers. The statistical methods used in all case series

Table 1 Search terms and retrieved results

Search set	Terms	Results
#1	Vacuum assisted closure (MeSH Terms) AND Pleural empyema (MeSH Terms)	47
#2	Negative pressure wound therapy (MeSH Terms) AND Pleural empyema (MeSH Terms)	47
#3	Intrathoracic vacuum therapy (MeSH Terms) AND Pleural empyema (MeSH Terms)	13

MeSH, medical subject headings.

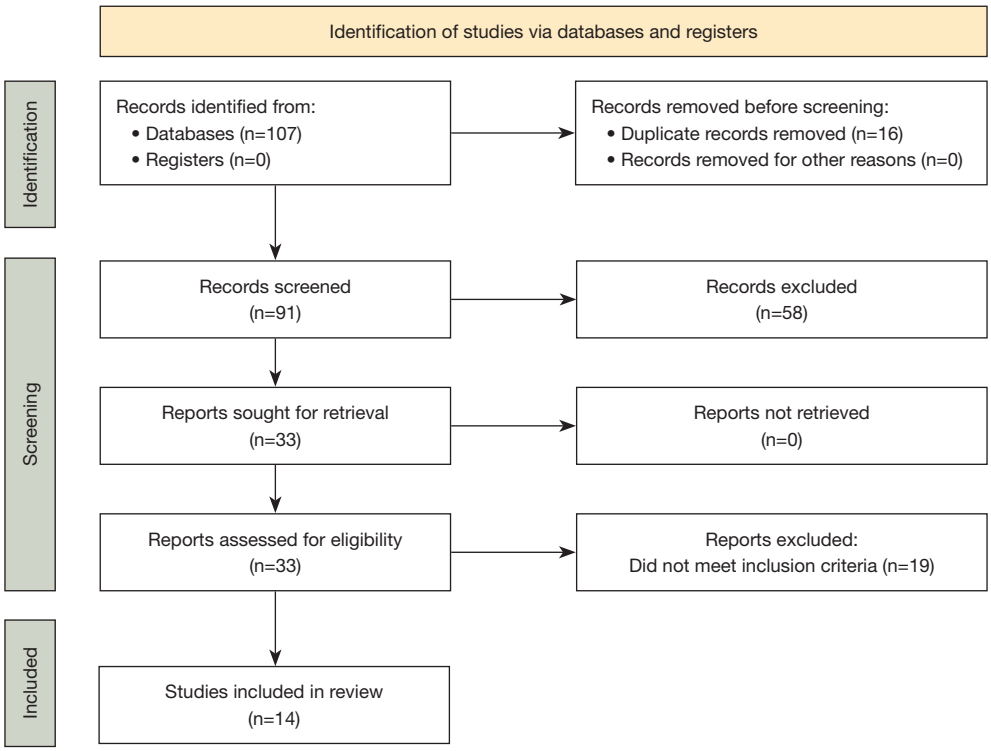

Figure 1 Flow chart.

were not sufficient to make statements about significant treatment differences.

Results

Description of studies

A total of 33 publications were found using the search strategy (*Table 1*). We screened the titles and abstracts of 33 records and discarded 19 records, as they did not meet the inclusion criteria. We obtained the full text of 14 articles for in-depth review to be included in this review. The PRISMA flowchart is shown in *Figure 1*.

Eight case series from Germany, one case series from Turkey, two from the USA, and one from the Netherlands, Switzerland and Japan were analysed.

Three case series reported on the use of the Instill-vacuum system (19,20), eight on conventional vacuum sponge therapy (15,16,21-25) and 2 on the mini-vacuum therapy (26). One series combined the mini-vacuum therapy with instill-vacuum technology (27), while one study compared all three vacuum types with each other (28).

Studies and patient characteristics

The 14 studies included assessed 165 patients. The median age was 64 years, ranging from 23 to 94 years. There was a predominance of male patients (78.7% *vs.* 21.4%) (*Table 2*).

Even though in most of the studies patients were

Table 2 Studies included and patient characteristics

Author	Year	Country	Patients (n)	Male (n)	Female (n)	Age [years, median (range)]
Al-Mufarrej *et al.* (21)	2010	USA	6	5	1	55.5 [23–72]
Aru *et al.* (22)	2010	USA	5	3	2	51 [41–61]
Ditterich *et al.* (23)	2006	Germany	3	1	2	75 [41–95]
Hofmann *et al.* (19)	2015	Germany	3	2	1	75 [56–87]
Karapinar *et al.* (15)	2016	Turkey	8	8	0	59.5 [49–86]
Nishii *et al.* (16)	2021	Japan	10	7	3	73.5 [53–77]
Palmen *et al.* (24)	2009	The Netherlands	11	8	3	51 [23–73]
Schreiner *et al.* (20)	2013	Germany	7	5	2	50 [32–74]
Sziklavari *et al.* (25)	2011	Germany	8	8	0	68 [53–76]
Sziklavari *et al.* (26)	2013	Germany	6	5	1	53.5 [41–72]
Sziklavari *et al.* (28)	2016	Germany	43	39	4	64 [25–91]
Sziklavari *et al.* (27)	2015	Germany	15	13	2	71 [25–91]
Groetzner *et al.* (14)	2009	Germany	13	11	2	60 [41–82]
Saadi *et al.* (17)	2011	Switzerland	27	15	12	64 [37–77]

judged as highly morbid, only very few detailed data for comorbidities were available (not shown).

All patients in the reported trials received concomitant antibiotic therapy. Success rates ranged from 66.7–100%, with 4 trials reporting a success rate of 100%. Recurrences with the need for revisional surgery were reported in 4 case series.

All but 3 series included patients with bronchopulmonary fistulas (BPF) following pulmonary resection, with BPF rates ranging from 0–80%.

Cause of empyema

Overall, 105 of 165 patients (63.6%) had empyema following surgical procedures. The most common procedures were lobectomy (29 patients) and pneumonectomy (27 patients). However, there was a large variety of procedures including Pancoast resection, oesophagus resection, sternotomy for aortic rupture and vertebral spine fusion.

Among the patients without prior surgical procedures (60 patients, 36.4%) the leading causes of pleural empyema were primary empyema (35 patients) and pneumonia. Other causes like pneumothorax or liver abscess were rare (*Table 3*).

Outcomes

We compared the reviewed studies with existing meta-analyses (6) or large cohort studies (10,11) considering either drainage or surgical treatment of pleural empyema.

Vacuum therapy, duration and interval of changes

In 71.5% of the cases (118 patients) vacuum therapy was applicated following OWT. Some authors applied vacuum sponge systems at the same time as OWT creation (17,25,28), while others applied the vacuum sponge several days after initial OWT creation (16,24). The mini-vacuum therapy was used in 14 patients (8.5%) and instill-vacuum therapy in 33 patients (20.0%).

The sub-atmospheric pressure applied to the vacuum sponge dressing ranged from 25–125 mmHg, with most authors using 75–125 mmHg. The interval of changes of the vacuum sponge systems varied from 2 to 7 days. The median number of vacuum sponge changes was between 1 and 13.

The overall duration of treatment ranged from medians of 6–120 days in the existing studies for patients treated by vacuum sponge (*Table 4*). While the treatment duration does appear long in these studies, it should be mentioned that 10 studies included in the review used the vacuum sponge system for patients with an OWT (*Table 5*). Taking into account the reports on OWT-outcomes by Reyes *et al.* (11) and Regnard *et al.* (10) with median treatment times of 454

Table 3 Causes of pleura empyema

Author	Year	Patients (n)	Cause of pleural empyema [n]
Al-Mufarrej *et al.* (21)	2010	6	Lobectomy [4]; pneumonectomy [2]
Aru *et al.* (22)	2010	5	Pneumonia [4]; Pneumonectomy [1]
Ditterich *et al.* (23)	2006	3	Pneumonia [1]; lobectomy [1]; penetrating thoracic wall abscess [1]
Hofmann *et al.* (19)	2015	3	Pneumonia [2]; thoracotomy [1]
Karapinar *et al.* (15)	2016	8	Pneumonectomy [8]
Nishii *et al.* (16)	2021	10	Pneumonia [5]; lung resection [2]; secondary pneumothorax [1]; chest drain related infection [1]; liver abscess [1]
Palmen *et al.* (24)	2009	11	Lobectomy [4]; pneumonia [2]; traumatic pneumothorax [2]; chronic tuberculosis [1]; recurrent pneumothorax [1]; trapped lung after benign pleural effusion [1]
Schreiner *et al.* (20)	2013	7	Lobectomy [2]; Pneumonectomy [2]; Primary empyema [2]; Chronic empyema [1]
Sziklavari *et al.* (25)	2011	8	Lobectomy [3]; Primary empyema [2]; Decortication [2]; Pneumonectomy [1]; Chest wall reconstruction [1]; Lung volume reduction [1]
Sziklavari *et al.* (26)	2013	6	Lobectomy [2]; Wedge-resection [1]; Sternotomy for aortic rupture [1]; Decortication for Boerhaave-syndrome [1]; Primary empyema [1]
Sziklavari *et al.* (28)	2016	43	Primary empyema [17]; Other thoracic procedures [15]; Pneumonectomy [6]; Lobectomy [5]
Sziklavari *et al.* (27)	2015	15	Primary empyema [8]; Lobectomy [3]; Pneumonectomy [2]; Vertebral spine fusion [1]; Oesophagus resection [1]
Groetzner *et al.* (14)	2009	13	Primary empyema [5]; Lobectomy [4]; Pneumonectomy [3]; Pancoast resection [1]
Saadi *et al.* (17)	2011	27	Intrathoracic gastrointestinal leaks [12]; Pneumonia [7]; Lobectomy [4]; Bilobectomy [2]; Pneumonectomy [2]

and 182.5 days respectively (*Table 6*), there does appear to be some benefit to the addition of vacuum sponge therapy in these cases.

Only 4 studies applied the vacuum sponge system without the use of an OWT (19,26-28). In these cases, the vacuum dressings (black polyurethane ester dressing) were applied using Alexis wound retractors without the need for an OWT or rib resection. In these reports, median treatment time ranged from 7–14 days. This appears to be in line with the report by Redden *et al.* which analysed VATS and open thoracotomy with drainage thoracostomy in a meta-analysis (6).

Length of stay, morbidity and mortality

The mean length of stay ranges from 44.5 to 216.7 days. Overall, in-hospital mortality was 5.5%. Four studies with a total of 13 patients performed vacuum therapy in ambulatory settings (14,21,22,25).

Generally, vacuum sponge-related complications were rare. Treatment-related complications were reported in 2 studies; One series showed one case of bleeding from the internal mammary vein (17), while another series showed two cases of increased visible pulmonary air leakage and two cases of empyema related sepsis (16).

Discussion

Our systematic review of the existing literature of pleural vacuum therapy for empyema identified a total of 14 case series and retrospective patient groups. Most authors presented either single case reports (which were excluded in this review) or retrospective case series. Low case numbers, lack of randomisation as well as inadequate or no statistical evaluation in these studies suggest low quality of the data published regarding this therapy so far. Although the current evidence is poor, this comprehensive literature review gives an overall impression of the potential that thoracic vacuum therapy holds for the treatment of pleural empyema. A total of 165 patients were included in this review, of which 101 (61.2%) were patients with an empyema secondary to thoracic surgery. While outcomes

Table 4 Duration of vacuum therapy, number, and interval of changes of the vacuum-system

Author	Year	Therapy	Changes of vacuum system (n), median [range]	Interval of changes (d)	Duration of therapy (d), median [range]
Al-Mufarrej *et al.* (21)	2010	OWT/VAC	6 [5–8]	2–4	64 [40–79]
Aru *et al.* (22)	2010	OWT/VAC	11 [3–20]	2–3	NA
Ditterich *et al.* (23)	2006	OWT/VAC	7 [4–40]	3	120 [12–122]
Hofmann *et al.* (19)	2015	Instill-VAC	1 [1–3]	3–4	7 [5–12]
Karapinar *et al.* (15)	2016	OWT/VAC	6 [6–6]	3	18 [18–18]
Nishii *et al.* (16)	2021	OWT/VAC	NA	3–4	59 [4–190]
Palmen *et al.* (24)	2009	Instill-VAC	NA	3–5	31 [12–50]
Schreiner *et al.* (20)	2013	OWT/VAC	NA	NA	6 [6–10]
Sziklavari *et al.* (25)	2011	OWT/VAC	2 [1–4]	3–7	NA
Sziklavari *et al.* (26)	2013	Mini-VAC	2 [1–4]	3–5	11.5 [4–18]
Sziklavari *et al.* (28)	2016	Instill-VAC Mini-VAC OWT/VAC	2 [1–6]	3–4	14 [5–48]
Sziklavari *et al.* (27)	2015	Instill-VAC	1 [1–5]	3–4	9 [5–25]
Groetzner *et al.* (14)	2009	OWT/VAC	13 [3–32]	2–4	64 [10–134]
Saadi *et al.* (17)	2011	OWT/VAC	6 [2–16]	2–4	22 [5–66]

OWT, open window thoracostomy; VAC, vacuum therapy; NA, not applicable.

Table 5 Length of stay, success-rate of treatment, vacuum therapy-related morbidity and in-hospital mortality

Author	Year	Length of stay, mean (SD) or [range]	Success rate	Vacuum-related morbidity	In-hospital mortality
Al-Mufarrej *et al.* (21)	2010	NA	66.7%	0%	0%
Aru *et al.* (22)	2010	46 (26.3)	100%	0%	0%
Ditterich *et al.* (23)	2006	97 (59.6)	100%	0%	33.3%
Hofmann *et al.* (19)	2015	NA	100%	0%	0%
Karapinar *et al.* (15)	2016	NA	75%	0%	0%
Nishii *et al.* (16)	2021	216.7 (168.6)	90%	20%	10%
Palmen *et al.* (24)	2009	NA	90.1%	0%	0%
Schreiner *et al.* (20)	2013	NA	85.7%	0%	14.3%
Sziklavari *et al.* (25)	2011	NA	87.5%	0%	12.5%
Sziklavari *et al.* (26)	2013	NA	100%	0%	0
Sziklavari *et al.* (28)	2016	NA	74.4%	0%	9.3%
Sziklavari *et al.* (27)	2015	NA	80%	0%	6.6%
Groetzner *et al.* (14)	2009	NA	84.6%	0%	0
Saadi *et al.* (17)	2011	44.5 [20–114]	81.5%	3.7%	18.5%

SD, standard deviation; NA, not applicable.

Table 6 Results of open window thoracostomy

Outcomes	Reyes *et al.* (11)	Regnard *et al.* (10)
Mortality (in hospital)	6.4%	4.3%
Treatment duration (days, median)	454 days (range, 90 days to 3 years)	182.5 days (range, 31–1,095 days)
Success rate (%)	97%	100%

were defined heterogeneously or sometimes not defined clearly at all in the studies analysed, a successful treatment outcome was defined by the authors of this review as discharge from hospital with a closed thoracic wound without the need for antibiotic therapy, re-intervention or renewed drain placement.

Three variations of the vacuum technique are described in the current literature: (I) conventional vacuum sponge treatment for pleural empyema is usually performed through an existing OWT. (II) The mini-vacuum technique described by Hofmann and colleagues uses an Alexis-Wound protector to insert the vacuum dressing without the need for OWT (29). (III) The Instill-vacuum therapy combines the traditional vacuum therapy with an automated, controlled antiseptic fluid delivery option, with the idea of flushing the cavity and reducing the bacterial load (19).

The technique is mostly used for the closure of OTW wounds or at least a volume reduction of these (30). Most patients with post-resection empyema received an OWT as treatment for the empyema, with vacuum treatment then applied to aid in the closure of these wounds. OWT is a salvage operation used for debilitated patients and patients who have failed either thoracostomy drainage or surgical therapy. These patients have significantly prolonged treatment, as shown in past reports on these patient populations (10,11).

Patients undergoing OWT treatment are usually poor surgical candidates either with complicated empyema not treatable with other treatment options, such as chest tube placement or surgery, or patients in whom these options have failed and where OWT is the last line of therapy. In the current literature there appears to be a selection bias of the most morbid patients with empyema who then receive vacuum sponge therapy to aid in the treatment of OWT and not as a first line treatment option for empyema.

The reporting of patient performance status is poor in the studies available for review. Only 4 studies cited the Karnofsky-Index as a marker for patient debilitation, with the mean Karnofsky-Index in these series <50%, demonstrating that these series performed vacuum therapy on extremely poor surgical candidates. It seems likely that the other series contained similarly ill patient populations, even though this can only be assumed due to insufficient reporting.

The patients with OWT treated with vacuum sponge therapy in the reviewed studies showed mortality rates of 0–33%, compared to 4.3% and 6.4% respectively in two large series for OWT (10,11). Other studies have reported mortality rates for OWT of up to 13.3% (31). The length of stay was only stated in 4 of 10 studies where vacuum therapy was used after OWT. The length of stay (days, mean) ranged from 44.5–216.7 days. This appears slightly longer than the range in other published articles on OWT, where the LOHS ranged from 4–150 days (10,32-34).

Intrathoracic vacuum treatment as a stand-alone therapy has a large potential in the therapy of empyema. The system is well established in other wounds and the dressing material can easily be adapted for intrathoracic use. In addition to the well-known black vacuum sponges, several materials such as open pore film and small pore sponges (white sponge) were developed to tailor an optimal therapy for every purpose and to influence the ingrowth rate of the material and the changing interval (35,36). The open pore film can be easily placed in a small room such as the thoracic cavity and to wrap the lung to affect a granulation stimulus on the complete empyema cavity.

Minimally invasive application techniques have been developed and refined to allow application without the need for single lung ventilation and could in some cases be carried out in analgo-sedation with propofol or midazolam, even in an outpatient setting. In the absence of the large tissue defect of an OWT for accessing the pleural cavity, minimally invasive procedures for example utilise the Alexis wound retractor to place or remove the vacuum foams (29). This means that a rib resection is not necessary, possibly leading to pain relief and higher levels of patient comfort. Even completely minimally invasive techniques have been developed, as shown in flexible endoscopic studies (37). Modifications including the vacuum-instill therapy

combining negative pressure treatment with intermittent irrigation of the wound showed promising results for achieving a sterile wound cavity (19). The possibility of ambulatory treatment promises a cost effectiveness by reducing the LOHS.

Vacuum sponge therapy also promises reduced postoperative morbidity and decreased risk of possibly life-threatening complications associated with empyema surgery. These include persistent air leaks, hemorrhage, injury to vital structures, severe postoperative pain, and sepsis. The latter in particular, is associated with high lethality in the case of septic shock due to resulting bacteremia, especially for elderly and multimorbid patients (38).

Vacuum therapy on the other hand can be applied solely on the parts of the lung which are affected and may thereby reduce the postoperative morbidity. Treatment related complications were rare in the patients reviewed in this paper, with only 2 patients showing prolonged air leakage and no revisional surgeries for postoperative bleeding being necessary.

The review of the current literature showed 4 studies that applied the vacuum system without the use of an OWT (19,26-28). Mortality rates of 0–9.3% are reported for these patients. While these are still higher than the published results in a large meta-analysis comparing thoracostomy drainage to open surgery and vacuum therapy (6), it seems likely that these higher mortality rates are due to a selection bias leading to patients which are poor surgical candidates due to debilitation being selected for vacuum treatment as a less invasive procedure. Additionally, the small sample size (67 patients across 4 studies) in the studies for vacuum therapy without OWT makes the comparability of mortality rates to a meta-analysis (6) (8 RCTs, 391 patients) difficult. LOHS could not be compared for vacuum therapy without OWT, as these data were not provided in the papers available for review. The median treatment time ranged from 7–14 days. This appears to be in line with the report by Redden *et al.* (6). Another drawback of the vacuum therapy is the need for several re-interventions associated with additional anesthesia exposure, potential complications, and stress for patients.

Overall, the standard of reporting complications, comorbidities and other treatment parameters was poor in all studies. The RAPID score could not be assessed for any patients, neither were intensive care unit treatment times documented. The authors of this paper believe that the condition of patients with pleural empyema should be clearly analysed and documented using a validated scoring system such as the Karnofsky Performance Index and/or the RAPID score. The RAPID score has been shown to accurately predict treatment outcomes in patients with pleural empyema (39). Improvements in the RAPID score and/or Karnofsky Performance Index should also be used to evaluate the treatment outcomes.

Follow-up ranged widely across studies, from no follow-up to a maximum of 96 months. Some studies reported LOS, while others only reported length of stay after first vacuum sponge application. These parameters could therefore not be assessed with any large degree of confidence.

The heterogenous patient cohorts across all analysed studies also makes it difficult to assess the quality of treatment for different causes of empyema. For example, intersitial pneumonia may lead to contractile changes in the lungs, inhibiting their re-expansion needed for reduction of the empyema cavity. Further studies should focus on patients with just one cause of empyema to allow an analysis of more homogenous patient groups. However, the tissue softening of the empyema capsule through vacuum therapy may lead to a reduction of the empyema cavity independent of interstitial lung changes.

Conclusions

In summary, it must be stated that the current level of evidence is poor, but the reports included in this review point in the direction of safe use of intrathoracic vacuum therapy for pleural empyema, with the potential of outpatient treatment to reduce LOHS. Vacuum sponge therapy does not only add a treatment option to otherwise inoperable, critically ill patients but might be a potential treatment alternative to the 'normal' pleural empyema stage II and III candidate. More data and larger scaled analyses are needed to further validate the potential of thoracic vacuum therapy in pleural empyema, optimally prospective or randomised control trials comparing minimally invasive vacuum sponge therapy with VATS decortication for patients with pleural empyema.

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Footnote

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