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**Current approach for Boerhaaves syndrome: A systematic review of case reports**

Yamana I *et al*. Current approach for Boerhaaves syndrome

Ippei Yamana, Takahisa Fujikawa, Yuichiro Kawamura, Suguru Hasegawa

**Ippei Yamana, Takahisa Fujikawa, Yuichiro Kawamura,** Department of Surgery, Kokura Memorial Hospital, Kitakyushu, Fukuoka 802-8555, Japan

**Suguru Hasegawa,** Department of Gastroenterological Surgery, Fukuoka University School of Medicine, Fukuoka 814-0180, Japan

**Author contributions:** Yamana I and Fujikawa T contributed equally to this work; Yamana I and Fujikawa T designed the research study; Yamana I and Fujikawa T performed the research; Kawamura Y contributed new reagents and analytic tools; Yamana I analyzed the data and wrote the manuscript; All authors have read and approve the final manuscript.

**Corresponding author: Takahisa Fujikawa, FACS, MD, PhD, Chief Doctor,** Department of Surgery, Kokura Memorial Hospital, 3-2-1 Asano, Kokurakita-ku, Kitakyushu, Fukuoka 802-8555, Japan. fujikawa-t@kokurakinen.or.jp

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**Abstract**

BACKGROUND

There is no consensus on the appropriate therapeutic strategy for Boerhaave syndrome due to its rarity and changing therapeutic approaches. We conducted a systematic review of case reports documenting Boerhaave syndrome.

AIM

To assess the therapeutic methods and clinical outcomes and discuss the current trends in the management of Boerhaave syndrome.

METHODS

We searched PubMed, Google scholar, Medline, and The Cochrane Library for studies concerning Boerhaave syndrome published between 2017 and 2022.

RESULTS

Of the included studies, 49 were case reports, including a total of 56 cases. The mean age was 55.8 ± 16 years old. Initial conservative treatment was performed in 25 cases, while operation was performed in 31 cases. The rate of conservative treatment was significantly higher than that of operation in cases of shock vital on admission (9.7% *vs* 44.0%; *P* = 0.005). Seventeen out of 25 conservative cases (68.0%) were initially treated endoscopic esophageal stenting; 2 of those 17 cases subsequently underwent operation due to poor infection control. Twelve cases developed postoperative leakage (38.7%), and 4 of those 12 cases underwent endoscopic esophageal stenting to stop the leakage. The length of the hospital stay was not significantly different between the conservative treatment and operation cases (operation *vs* conservation: 33.52 ± 22.69 *vs* 38.81 ± 35.28 days; *P* = 0.553).

CONCLUSION

In the treatment of Boerhaave syndrome, it is most important to diagnose the issue immediately. Primary repair with reinforcement is the gold-standard procedure. The indication of endoscopic esophageal stenting or endoluminal vacuum-assisted therapy should always be considered for patients in a poor general condition and who continue to have leakage after repair.

**Key Words:** Boerhaave syndrome; Esophageal perforation; Self expandable metalic stent; Minimally invasive surgical procedures; Anastomotic leakage; Shock

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**Core Tip:** Totally 49 published case reports concerning the Boerhaave syndrome were systematically reviewed. In the treatment of Boerhaave syndrome, it is most important to diagnose the issue immediately. Primary repair with reinforcement is the gold-standard procedure. The indication of endoscopic esophageal stenting or endoluminal vacuum-assisted therapy should always be considered for patients in a poor general condition and who continue to have leakage after repair.

**INTRODUCTION**

Since Herman Boerhaave first recognized the disease in 1724, spontaneous esophageal perforation has been described as a medical emergency in the relevant literature[1]. The annual incidence of spontaneous esophageal perforation, also called Boerhaave syndrome, is 3.1 per 1000000; although rare, this condition is associated with high rates of misdiagnosis and mortality[2].

Boerhaave syndrome can be caused by vomiting and is frequently associated with alcohol intoxication[3]. A long period of time between perforation and treatment often results in mediastinitis, followed by septic shock and multiorgan failure[4-10]. Surgery and conservative management are the major treatment options for Boerhaave syndrome. However, few reports have examined whether operation or conservation is the preferred treatment method. Indeed, in the past five years, only one systematic review of Australasian literature on Boerhaave syndrome has been reported[11]. At present, there is no consensus on the optimal therapeutic strategy due to the rarity of Boerhaave syndrome and changing therapeutic approaches.

We therefore reviewed and evaluated 56 cases published in 49 case report articles in PubMed, Google scholar, Medline, and The Cochrane Library in the past 5 years to assess the therapeutic methods and clinical outcomes and discuss the current trends in the management of Boerhaave syndrome.

**MATERIALS AND METHODS**

***Study selection***

A case report literature review was conducted using Pubmed, Google scholar, Cochrane Library, and Medline for articles published between October 2017 and October 2022. The search was limited to articles in English. “Boerhaave syndrome” or “spontaneous esophageal perforation” were key words in the search. All titles and abstracts of publications were screened to select articles describing Boerhaave syndrome or spontaneous esophageal perforation. The searches were further broadened by extensively checking all references in the articles retrieved that met the inclusion criteria.

***Inclusion and exclusion criteria***

The inclusion criterion was patients who underwent operation or conservative therapy for Boerhaave syndrome. The exclusion criteria were meta-analyses, reviews, articles without outcomes reported, articles without the operation method reported, articles involving cases of treatment refusal, articles involving recurrent cases of esophageal perforation, articles involving best supportive care, articles involving pediatric cases, articles focusing on other diseases, and articles in non-English languages.

***Data extraction***

The study design, and data on the patients’ demographics, interventions, and outcomes were extracted from the included studies. An independent researcher collected the study data using a standard Excel™ data collection sheet (Microsoft Corporation, Japan). This spreadsheet was used to calculate the descriptive statistics of all parameters that were evaluated in the present study. Continuous and categorical variables were shown as the mean and standard deviation (SD) and range.

***Quality appraisal***

The overall quality of the cases was classified as good to moderate. The majority of patients adequately described the chief complaint (100%), the patient’s medical history (82.1%), the sex (98.2%), the length from symptom onset (98.2%), the length of the hospital stay (76.8%), imaging findings (100%), treatments (100%), and outcomes (100%).

***Statistical analyses***

 All values were presented as the mean ± SD. Intergroup differences were evaluated by an analysis of variance, while a nonparametric analysis was conducted for data with a skewed distribution. Statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University)[12]. EZR for R (The R Foundation for Statistical Computing, version 2.13.0) is a modified version of the R commander (version 1.6–3) that includes statistical functions that are frequently used in biostatistics. *P* values of < 0.05 were considered statistically significant.

**RESULTS**

The results of the literature search are shown in Figure 1. Through our search, we identified 1310 studies. Of these, 990 studies were excluded by title and abstract. Of the remaining 115 potentially relevant articles, we excluded 48 concerning other diseases, 11 with insufficient data, 3 concerning recurrence cases, 2 involving best supportive care, and 2 pediatric cases. This resulted in the inclusion of 49 case report articles involving 56 cases for this study.

***Patients’ characteristics***

 Table 1 shows the details of the included studies. Of the 55 patients whose sex was mentioned, 51 were male, and 4 were female (1 case with no information). The mean age was 55.8 ± 16 years old. Thirty-six of the 55 cases (65.5%) were referred to the hospital within 24 h after symptom onset (1 case with no information). The most common method of the diagnosis was computed tomography (*n* = 31), followed by esophagography (*n* = 15), endoscopy (*n* = 9), and exploratory laparotomy (*n* = 1). A total of 42 cases (75%) were accurately diagnosed on admission. Fourteen patients (25%) showed shock vitals when they arrived at the hospital. Twelve (21.4%) were intra-mediastinum type, and 44 (78.6%) were extra-mediastinum type. The mean (range) size of the laceration in the 30 cases for which such details were described was 3.8 (1-12) cm (Table 2).

***Initial treatment for Boerhaave syndrome***

Conservative treatment was performed in 25 cases, while operation was performed in 31 cases. Conservative treatment included endoscopic esophageal stents in 17 cases, endoscopic clipping in 5, thoracic drainage in 21, and endoluminal vacuum-assisted (EVAC) therapy in 1. The operation approach was trans-thoracic and trans-abdominal approaches in 18 and 10 cases, respectively; a combined trans-abdominal and trans-thoracic approach was performed in 3 cases. In the trans-thoracic approach, minimally invasive surgery was performed in 5 cases (23.8%). In the trans-abdominal approach, minimally invasive surgery was performed in 8 cases (61.5%). The operation methods were primary repair only in eight cases, primary repair with omentoplasty in six cases, primary repair with fundus pouch in six cases, primary repair with intercostal muscle pouch in five cases, primary repair with pericardial fat pouch in five cases, T tube in two cases, esophagectomy in one case, and esophagostomy in one case. Twelve out of 31 cases (38.7%) developed postoperative leakage. Two of those cases underwent EVAC therapy, and four of the cases underwent endoscopic esophageal stenting. Seven out of the 56 total cases (12.5%) died following treatment for Boerhaave syndrome; notably, 4 of those 7 cases (57.1%) had already had shock vitals on arrival at the hospital (Table 3).

***Endoscopic esophageal stenting***

Seventeen cases underwent endoscopic esophageal stenting initially, and 14 of them (82.4%) had severe comorbidities. Ten of the 17 cases (58.8%) who underwent endoscopic esophageal stenting had had shock vitals on arrival at the hospital. One case (14.3%) was the intra-mediastinum type, while the other 16 (85.7%) were the extra-mediastinum type. Two of the 17 cases who underwent endoscopic esophageal stenting had initially undergone operation due to poor infection control.

Four of the cases who initially underwent operation consequently underwent endoscopic esophageal stenting to stop leakage.

***Minimally invasive surgery***

Eleven out of 31 cases (35.5%) underwent minimally invasive surgery. Seven of the 13 cases (53.8%) who underwent the trans-abdominal approach received the trans-hiatal approach specifically with laparoscopic surgery. Five of the 21 cases (23.8%) who underwent the trans-thoracic approach received thoracoscopic surgery. The length of the hospital stay after surgery tended to be shorter with minimally invasive surgery than with non-minimally invasive surgery [minimally invasive surgery (*n* = 10) *vs* non-minimally invasive surgery (*n* = 15): 25.5 ± 17.1 *vs* 38.86 ± 24.85 d; *P* = 0.153] (Figure 2A).

***Conservative treatment vs surgery***

Table 4 shows the differences in details between patients who underwent an operation and those who received conservative treatment. The sex, age, rate of patients admitting within 24h after symptom onset, rupture type, and rate of survival did not significantly differ between patients who underwent an operation and those who received conservative treatment. The rate of patients with shock vitals on admission did differ significantly between patients who underwent an operation and those who received conservative treatment (9.7% *vs* 44.0%; *P* = 0.005). The length of hospital stay was not significantly different among the 43 cases (operation *vs* conservative treatment: 33.52 ± 22.09 *vs* 38.81 ± 35.28 d; *P* = 0.55) (Figure 2B).

**DISCUSSION**

Primary surgical repair has been the gold-standard treatment for esophageal perforation for a long time[13-19]. Primary repair of the esophagus conducted with mediastinal and thoracic drainage is reported to have a 90% success rate. Cases in which esophageal rupture is diagnosed at an early stage (within 24 h) without associated esophageal disease are reported to show a particularly high success rate[20]. There has been a recent trend toward more non-operative management[21,22], such as esophageal stent replacement *via* an endoscopic approach[23-32]. The indications for esophageal stenting include multiple comorbidities, advanced mediastinal sepsis, hemodynamic compromise, and clinical intolerance of extensive surgical repair[33]. In our review, the rate of conservation was significantly higher than that of operation in instances of shock vital on admission (44.0% *vs* 9.7%; *P* = 0.005).

Esophageal stenting was able to be attempted for patients who were in a bad general condition or intolerant to surgery[34]. Endoscopic esophageal stenting was also performed for cases of postoperative leakage. Kauer *et al*[35] in 2008 first described the usefulness of stent placement in the management of thoracic anastomotic leakage after esophagectomy. An interval approach utilizing covered metallic stent was then introduced for the management of anastomotic leakage after esophagectomy[36]. However, no prospective clinical study comparing the outcomes of esophageal stenting to that of conservative/surgical treatment has yet been performed. Bi *et al*[37] reported that the efficacy of the three-tube method, (tube drainage of the abscess, placement of a jejunal feeding tube, and placement of a gastrointestinal decompression tube, with implantation of a covered metallic stent) for the management of anastomotic leakage following esophagectomy. This means that it is important not only to place esophageal stents but also to provide adequate drainage, a concept that can also be applied for treating Boerhaave syndrome.

Surgical approaches differed among facilities in our review. The operation approach in our evaluated studies was the trans-thoracic approach in 18 cases, trans-abdominal approach in 10 cases, and combined trans-thoracic and trans-abdominal approach in 3 cases. The approach seemed to differ depending on laceration site, the patient’s general condition, and whether the operator was a thoracic surgeon or a gastrointestinal surgeon. The reported operative methods for Boerhaave syndrome include primary repair (with/without reinforcement), an exclusion diversion operation[38], esophageal resection, and simple thoracic drainage[39-40]. Previous reports mentioned that reinforcement with vascularized tissue was associated with reduced fistula formation and mortality rates in comparison to repair without reinforcement41-43. In the case of friability of the tissue, primary repair with reinforcement, such as omental flaps[44-47], intercostal muscle flaps[48-51], and pericardial flaps[52-54], should be performed. A comprehensive evaluation of the degree of laceration, extent of laceration, and general condition required for deciding the repair method should be conducted.

There have been a few recent reports concerning minimally invasive surgery for Boerhaave syndrome. Kita *et al*[55] suggested that a good clinical course can be obtained by laparoscopic trans-hiatal esophageal repair for Boerhaave's syndrome with localized mediastinal collections to avoid surgical invasion due to thoracotomy. Sekiya *et al*[56] reported the convenience and usefulness of minimally invasive surgery via an abdominal and left thoracic approach, which provides excellent visualization of the abdominal and thoracic cavities and facilitates quick switching between views. The authors further suggested that, in cases with an interval to the diagnosis < 24 h, no severe comorbidities, and a perforation site in the left lower esophagus, a trans-hiatal approach for minimally invasive surgery is feasible to repair the laceration and ameliorate the infection[56]. In our systematic review, the length of hospital stay after minimally invasive surgery tended to be shorter than after non-minimally invasive surgery (25.5 ± 17.1 *vs* 38.86 ± 24.85 d; *P* = 0.153). Minimally invasive surgery is useful for its cosmetic aspect, camera magnification effect, and ease of suturing, especially a laparoscopic trans-hiatal approach.

In our systematic review, 12 out of 31 cases (38.7%) developed postoperative leakage. Two of those 13 Leakage cases underwent EVAC therapy. Recently, the efficacy of EVAC therapy for esophago-pleural fistula after an operation for Boerhaave syndrome was reported[57-59]. EVAC therapy can be applied in postoperative management according to the principle applied for external wounds that provide wound drainage and tissue granulation. EVAC therapy can be applied to conservatively treat cases where primary surgical repair of esophageal perforation is unsuccessful. Moreover, with the use of an S-B tube, the patient can simultaneously receive intraluminal EVAC therapy with enteral nutrition in a non-invasive manner[58]. This may accelerate the healing of the injured esophagus and reduce the duration of hospitalization.

We suggest an algorithm that might be useful in the treatment of Boerhaave syndrome in Figure 3, with reference to our systematic review. If Boerhaave syndrome is suspected on computed tomography, esophagography or upper gastrointestinal endoscopy should be performed immediately. The treatment of Boerhaave syndrome is basically primary repair with reinforcement. If postoperative leakage occurs, endoscopic esophageal stenting or EVAC therapy should be considered. If the patient is inoperable (severe shock vitals, super-elderly patients, severe comorbidities, *etc.*), endoscopic esophageal stenting and thoracic drainage should be considered.

Several limitations associated with the present study warrant mention. Importantly, due to its rarity, there are few large case series on Boerhaave syndrome. Furthermore, the therapeutic strategies for Boerhaave syndrome have changed over time, with new approaches being developed recently. We reviewed and analyzed 49 articles; however, the review process may have included various publication biases.

**CONCLUSION**

In the treatment of Boerhaave syndrome, it is most important to diagnose the issue immediately. Primary repair with reinforcement is the gold-standard procedure. The optimal treatment should be determined according to the etiology, general physical condition of the patient, and site of perforation, as well as the extent of contamination, as determined by radiology. The indication of endoscopic esophageal stenting or endoluminal vacuum-assisted therapy should always be considered for patients in a poor general condition and who continue to have leakage after repair.

**ARTICLE HIGHLIGHTS**

***Research perspectives***

As far, it has long been reported that Boerhaave syndrome has a poor prognosis when diagnosed late. However, no consensus has been reached concerning the appropriate therapeutic strategy for Boerhaave syndrome because of the rarity of the disease and the changing therapeutic trends.

***Research conclusions***

We assess the therapeutic methods (operation *vs* drainage *vs* stent *vs* EVAC, *etc.*) and clinical outcomes and discuss the current trends in the management of Boerhaave syndrome.

***Research results***

We believe that this systematic review will be useful in future treatment of Boerhaave syndrome when there is doubt as to whether conservative treatment or surgery should be done, as well as the method of surgery.

***Research methods***

We searched PubMed, Google scholar, Medline, and The Cochrane Library for studies concerning Boerhaave syndrome published between 2017 and 2022.

***Research objectives***

In results, the key to treatment of Boerhaave syndrome was early diagnosis. In addition, although surgery was the basic treatment, esophageal stents and drainage may be useful for patients with intolerance. Furthermore, for postoperative leakage, esophageal stents, drainage, and EVAC were useful.

***Research motivation***

In the treatment of Boerhaave syndrome, it is most important to diagnose the issue immediately. Primary repair with reinforcement is the gold-standard procedure. The indication of endoscopic esophageal stenting or endoluminal vacuum-assisted therapy should always be considered for patients in a poor general condition and who continue to have leakage after repair.

***Research background***

Because Boerhaave syndrome is a rare disease, observational studies should be conducted in collaboration with other centers. We hope that this will result in a high-quality strategy.

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**Figure Legends**



**Figure 1 PRISMA flow diagram demonstrating articles selection process.**



**Figure 2 Comparison of length of hospital stay.** A: The length of hospital stay in the non-minimally and minimally invasive surgery groups; B: The length of hospital stay in the operation and conservative treatment groups.

**Figure 3 Algorithm for the treatment of Boerhaave syndrome with reference to the systematic review findings.**

**Table 1 Descriptive comparative characteristics of all included 49 studies**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ref.** | **Age** | **Sex** | **Accurate diagnosis** | **Rupture type** | **Shock vital** | **Laceration size (cm)** | **Treatment** | **Prognosis** |
| Jahangir *et al*[ 4], 2021 | 64 | M | Yes | Intrapleural type | Yes | 1 | Stent, thoracic drainage | Death |
| Issa *et al*[23], 2019 | 32 | M | Yes | Intrapleural type | No | 2 | Stent, thoracic drainage | Alive |
| Tan *et al*[5], 2022 | 84 | M | No | Intrapleural type | No | Unknown | Thoracotomy, primary repair only | Death |
| Chang *et al*[13], 2021 | 67 | M | Yes | Intrapleural type | No | 3 | Thoracopy, primary repair only, feeding jejunostomy | Alive |
| Chang *et al*[13], 2021 | 62 | M | Yes | Intrapleural type | No | 2 | Thoracopy, primary repair only, feeding jejunostomy | Alive |
| Sheshala *et al*[24], 2021 | 39 | M | No | Intrapleural type | Yes | Unknown | Stent, thoracic drainage | Alive |
| Matsumoto *et al*[25], 2019 | 60 | M | No | Intrapleural type | Yes | Unknown | Stent, thoracic drainage | Alive |
| Ayazi *et al*[6], 2021 | 22 | M | Yes | Intrapleural type | Yes | Unknown | Thoracotomy, esophagectomy, gastrostomy | Death |
| Maki *et al*[44], 2022 | 76 | M | Yes | Intramediastinal type | No | 7 | Transhiatal approach, primary repair plus omentoplasty, feeding jejunostomy | Alive |
| Ioannidis *et al*[39], 2021 | 83 | F | Yes | Intrapleural type | No | Unknown | Thoracic drainage | Alive |
| Y K *et al*[26], 2018 | 86 | M | Yes | Intrapleural type | Yes | 5 | Stent, thoracic drainage, feeding jejunostomy | Alive |
| Czopnik *et al*[3], 2017 | 47 | M | Yes | Intrapleural type | No | 5 | Transhiatal approach, primary repair, gastrostomy | Alive |
| Awadelkarim *et al*[27], 2021 | 36 | M | Yes | Intrapleural type | Yes | 2 | Stent, thoracic drainage | Alive |
| Chalikonda *et al*[28], 2019 | 74 | M | No | Intrapleural type | Yes | Unknown | Stent, thoracic drainage | Alive |
| Śnieżyński *et al*[29], 2021 | 53 | M | Yes | Intrapleural type | No | 3 | Stent, thoracic drainage | Alive |
| Matsuura *et al*[21], 2022 | 69 | M | Yes | Intramediastinal type | No | Unknown | Endoscopic clipping | Alive |
| Chen *et al*[19], 2021 | 57 | M | No | Intramediastinal type | No | Unknown | Transhiatal approach, primary repair only, feeding jejunostomy | Alive |
| Truyens *et al*[30], 2020 | 66 | M | Yes | Intramediastinal type | Yes | Unknown | Antibiotic administration | Alive |
| Truyens *et al*[30], 2020 | 77 | M | Yes | Intramediastinal type | No | Unknown | Stent | Alive |
| Swol *et al*[7], 2019 | 70 | M | Yes | Intramediastinal type | No | 2 | Transhiatal approach, primary repair plus fundus pauch | Death |
| Park *et al*[45], 2021 | Unknown | Unknown | Yes | Intramediastinal type | No | 5 | Laparoscopic transhiatal approch, primary repair plus omentoplasty → endoscopic clipping, stent | Alive |
| Rahman *et al*[49], 2021 | 53 | M | Yes | Intrapleural type | No | Unknown | Thoracotomy, primary repair plus intercostal muscle pauch, gastro-jujuno tube → stent | Alive |
| Nachiappan *et al*[46], 2022 | 59 | M | No | Intrapleural type | No | 1,5 | Endscopic clipping, stent → laparoscopic transhiatal approach, primary repair plus omentoplasty | Alive |
| Pasternak *et al*[14], 2019 | 37 | M | Yes | Intrapleural type | No | Unknown | Thoracotomy, primary repair only, gastrostomy | Alive |
| Kita *et al*[55], 2022 | 46 | M | Yes | Intramediastinal type | No | 4 | Laparoscopic transhiatal approch, primary repair plus fundus pauch | Alive |
| Kita *et al*[55], 2022 | 48 | M | Yes | Intramediastinal type | No | 3 | Laparoscopic transhiatal approch, primary repair plus fundus pauch | Alive |
| Kita *et al*[55], 2022 | 65 | M | Yes | Intramediastinal type | No | 5 | Laparoscopic transhiatal approch, primary repair plus fundus pauch | Alive |
| Saffo *et al*[8], 2021 | 76 | M | No | Intrapleural type | Yes | Unknown | Stent, thoracic drainage | Death |
| Kochar *et al*[50], 2019 | 40 | M | Yes | Intrapleural type | Yes | Unknown | Thoracotomy, primary repair plus intercostal muscle pauch, intraoperative stent, thoracic drainage | Alive |
| Bury *et al*[51], 2022 | 50 | M | No | Intrapleural type | No | 4 | Thoracotomy, primary repair plus intercostal muscle pauch, thoracic drainage | Alive |
| Aref *et al*[47], 2019 | 32 | M | Yes | Intramediastinal type | No | 2 | Laparoscopic transhiatal approach, primary repair plus omentoplasty | Alive |
| Bani Fawwaz *et al*[15], 2022 | 63 | M | Yes | Intrapleural type | Yes | 3 | Stent, thoracic drainage | Alive |
| Bani Fawwaz *et al*[15], 2022 | 56 | F | Yes | Intrapleural type | No | Unknown | Thoracotomy, primary repair plus T tube, Belsey fundoplication, intraoperative stent, thoracic drainage, gastrostpomy | Alive |
| Xu *et al*[22], 2021 | 63 | M | Yes | Intrapleural type | No | Unknown | Endoscopic clipping | Alive |
| Tuñon *et al*[57], 2021 | 24 | M | Yes | Intrapleural type | No | 4 | Endoluminal vacuum therapy → endoscopic clipping | Alive |
| Lee *et al*[58], 2018 | 52 | M | Yes | Intrapleural type | No | Unknown | Thoracoscopic approach, primary repair only → endoluminal vacuum therapy, thoracic drainage | Alive |
| He *et al*[54], 2018 | 57 | M | Yes | Intramediastinal type | No | 6 | Endoscopic clipping | Death |
| Kim *et al*[59], 2019 | 56 | M | Yes | Intrapleural type | No | Unknown | Thoracotomy, primary repair only → endoluminal vacuum therapy, thoracic drainage | Alive |
| Shennib *et al*[52], 2021 | 47 | M | No | Intrapleural type | Yes | 5 | Thoracotomy, primary repair plus pericardial pauch, gastrostomy, feeding jejunostomy | Alive |
| Agrawal *et al*[40], 2019 | 26 | M | No | Intrapleural type | No | Unknown | thoracic drainage | Alive |
| Sato *et al*[31], 2018 | 52 | M | Yes | Intrapleural type | No | Unknown | Thoracotomy, primary repair only → stent, thoracic drainage | Alive |
| Sato *et al*[31], 2018 | 53 | M | No | Intrapleural type | Yes | Unknown | Stent, thoracic drainage | Alive |
| Ali *et al*[16], 2020 | 30 | F | No | Intrapleural type | No | 4 | Thoracotomy, primary repair only | Alive |
| Anand *et al*[48], 2022 | 64 | M | Yes | Intrapleural type | No | 2 | Thoracotomy, primary repair plus intercostal muscle pauch, thoracic drainage | Alive |
| Barakat *et al*[32], 2017 | 62 | M | Yes | Intrapleural type | No | 1 | Stent, endoscopic clipping | Alive |
| Alakkari *et al*[17], 2019 | 69 | F | Yes | Intrapleural type | No | Unknown | Thoracotomy, primary repair plus T tube | Alive |
| Zhu *et al*[18], 2021 | 33 | M | No | Intrapleural type | No | Unknown | Stent, PEG →thoracotomy, drainage | Alive |
| Sekiya *et al*[56], 2019 | 61 | M | Yes | Intrapleural type | No | 3 | Thoracoscopic and laparoscopic approach, primary repair plus pericardial pauch, gastrostomy | Alive |
| Sekiya *et al*[56], 2019 | 64 | M | Yes | Intrapleural type | No | 4 | Thoracoscopic and laparoscopic approach, primary repair plus pericardial pauch, feeding jejunostomy | Alive |
| Olivero *et al*[53], 2019 | 67 | M | No | Intrapleural type | No | 2 | Thoracotomy, primary repair plus pericardial pauch, thoracic drainage | Alive |
| Felipe *et al*[38], 2021 | 47 | M | Yes | Intrapleural type | No | 12 | Thoracotomy and laparotomy approach, esophagostomy, gastrostomy → stent | Alive |
| Ahmad *et al*[33], 2018 | 63 | M | Yes | Intrapleural type | No | 2.5 | Stent, thoracic drainage | Alive |
| Hashmi *et al*[10], 2021 | 83 | M | Yes | Intrapleural type | Yes | Unknown | Antibiotic administration | Death |
| Teblick *et al*[34], 2018 | 74 | M | Yes | Intrapleural type | No | Unknown | Stent, thoracic drainage | Alive |
| He *et al*[9], 2018 | 27 | M | Yes | Intrapleural type | No | 6 | Thoracotomy, primary repair plus pleural flap, feeding jejunostomy | Alive |

PEG: Percutaneous endoscopic gastrostomy; M: Male; F: Female.

**Table 2 Characteristics of the patients with Boerhaave syndrome included in the review, *n* (%)**

|  |  |  |
| --- | --- | --- |
| Sex |  | aMale 51, female 4 |
| Age |  | 55.8 ± 16 |
| The length from symptom within 24 h  |  | b36 (65.5) |
| The method of diagnosis  | CT | 31 |
|  | Esophagography | 15 |
|  | Endoscopy | 9 |
|  | Exploratory laparotomy | 1 |
| Accurate diagnosis on admission  |  | 42 (75) |
| Shock vital on admission  |  | 14 (25) |
| Rupture type | Intramediastinal | 12 (21.4) |
|  | Extramediatinal | 44 (78.6) |
| Lacelation size (cm) (range) |  | c3.8 (1-12) |

aOne case with no information.

bOne case with no information.

c26 cases with no information.

CT: Computed tomography.

**Table 3 Initial treatment for Boerhaave syndrome**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  | **The number do not add up because of duplication case** |
| Conservation (*n* = 25)a | Esophageal stent |  | 17 |
|  | Clipping |  | 5 |
|  | Thoracic drainage |  | 21 |
|  | EVACb |  | 1 |
| Operation (*n* = 31) | Approach | Trans-thoracic approach | 18 |
|  |  | Trans-abdominal approach | 10 |
|  |  | Trans-thoracic and abdominal approach | 3 |
|  | Method | Primary repair only | 8 |
|  |  | Primary repair with omentoplasty | 6 |
|  |  | Primary repair with fundus pauch | 6 |
|  |  | Primary repair with intercostal muscle pauch | 5 |
|  |  | Primary repair with pericardial fat pauch | 5 |
|  |  | T tube | 2 |
|  |  | Esophagectomy | 1 |
|  |  | Esophagostomy and gastrostomy | 1 |

aDuplication exist.

bEndoluminal vacuum-assisted therapy.

EVAC: Endoluminal vacuum-assisted.

**Table 4 The length of hospital stay was not significantly different among the 43 cases**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Factor** | **Group** | **Operation (*n* = 31)** | **Conservation (*n* = 25)** | ***P* value** |
| Sex (%) | M | 27 (90.0)  | 24 (96.0)  | 0.617 |
|  | F | 3 (10.0)  | 1 ( 4.0)  |  |
| mean ± SD |  | 53.17 (14.68) | 59.00 (18.14) | 0.193 |
| The length from symptom within 24 h (%) | Yes | 10 (32.3)  | 9 (36.0)  | 1 |
|  | No | 20 (64.5)  | 16 (64.0)  |  |
| Shock vital on admission (%) | Yes | 3 ( 9.7)  | 11 (44.0)  | 0.005 |
|  | No | 28 (90.3)  | 14 (56.0)  |  |
| rupture type | Intramediastinal (%) | 8 (25.8)  | 4 (16.0)  | 0.516 |
|  | Extramediastinal (%) | 23 (74.2)  | 21 (84.0)  |  |
| Alive (%) | Yes | 28 (90.3)  | 21 (84.0)  | 0.688 |
|  | No | 3 ( 9.7)  | 4 (16.0)  |  |

F: Female; M: Male.



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