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Outcome of Patients with Esophageal Perforations: A Multicenter Study

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Abstract

Background Recent studies have suggested that stent-grafting may improve the treatment outcome of patients with esophageal perforation, but evidence on this is still lacking.

Methods Data on 194 patients who underwent conservative (43 patients), endoclip (4 patients) stent-grafting (63 patients) or surgical treatment (84 patients) for esophageal perforation were retrieved from nine medical centers.

Results In-hospital/30-day mortality was 17.5 %. Three-year survival was 67.1 %. Age, coronary artery disease, and esophageal malignancy were independent predictors of early mortality. Chi squared automatic interaction detection analysis showed that patients without coronary artery disease, without esophageal malignancy and younger than 70 years had the lowest early mortality (4.1 %). Surgery was associated with slightly lower early mortality (conservative 23.3, endoclips 25.0 %, stent-grafting 19.0 %, surgery 13.1 %; $p = 0.499$). One center reported a series of more than 20 patients treated with stent-grafting which achieved an early mortality of 7.7 % (2/26 patients). Stent-grafting was associated with better survival with salvaged esophagus (conservative 76.7 %, endoclips 75.0 %, stent-grafting 77.8 %, surgery 56.0 %; $p = 0.019$). Propensity score adjusted analysis showed that stent-grafting achieved similar early mortality ($p = 0.946$), but significantly higher survival with salvaged esophagus than with surgical treatment ($p = 0.001$, OR 0.253, 95 % CI 0.110–0.585). Primary surgical repair was associated with somewhat lower early mortality (14.6 vs. 19.0 %; $p = 0.561$) and better

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survival with salvaged esophagus (85.4 vs. 77.8 %; $p = 0.337$) than stent-grafting.
Conclusions Esophageal perforation was associated with a rather high mortality rate in this all-comers population. Stent-grafting failed to decrease operative mortality, but it improved survival with salvaged esophagus. The results of one of the centers indicate that increasing experience with this less invasive procedure may possibly improve the outcome of these patients.

Introduction

Barrett in 1947 was the first to report on successful aggressive surgical treatment of esophageal perforation [1]. Since then a number of treatment methods have been introduced to repair the perforation site and decrease local and systemic complications associated with this potentially fatal condition. Despite these approaches, esophageal perforation is still associated with significant mortality and morbidity requiring prolonged in-hospital treatment [2]. For this reason, prompt recognition and treatment of this condition is advocated [3]. Stent-grafting for esophageal perforation has been recently introduced as a less invasive approach than surgery, potentially reducing the extent of repair and enabling preservation of the esophagus [2, 4, 5]. However, its benefits are still largely unproven. The present multicenter study was performed to investigate the early and late outcome after esophageal perforation and, in particular, to compare the results of surgical treatment versus stent-grafting in this emergency condition.

Materials and methods

This is a multicenter study including 194 consecutive patients with esophageal perforation treated from January 2000 to February 2013 in nine tertiary referral hospitals from Finland, Norway, Iceland, France, and Italy. Data on baseline characteristics, operative treatment, and postoperative outcome were collected retrospectively from patients' records. Details on these variables and their definition criteria are reported elsewhere [6]. Permission to perform this study was obtained from the local ethics committees.

Esophageal perforation was defined as any transmural rupture of the esophagus diagnosed by computed tomography (CT) scan showing periesophageal air and fluid, pleural effusion, and contrast agent leakage. Esophageal anastomosis leakages were excluded from this analysis. The treatment was defined as delayed when initiated more than 24 h from the start of symptoms. Conservative treatment was defined as any treatment not including direct or indirect surgical repair of esophageal tear, exclusion with diversion, or stent-grafting of the esophagus. Two patients who underwent endoscopic drainage through the esophageal tear were included in the conservative treatment group.

Patients undergoing endoscopic repair of the esophageal tear with any kind of endoclips were included in the endoclips group.

Surgical treatment of the esophageal perforation was defined as any surgical repair of the tear with or without reinforcement, esophagectomy, or exclusion by cervical esophagostomy and gastrostomy. Endoluminal treatment was defined as repair of the esophageal perforation by stent-grafting. The present analysis was performed according to the intention-to-treat principle; i.e., patient data was analyzed according to the treatment group to which the patients were initially allocated. If stent-grafting or surgical repair were performed within the same day on which the conservative strategy was begun, then the former were considered as the main treatment method.

The main outcome measures of this study were all-cause mortality during the hospital stay and/or the 30-day postoperative period, and survival with salvaged esophagus. Secondary outcome endpoints were sepsis, stroke, myocardial infarction, excessive bleeding requiring operation, renal replacement therapy, intensive care unit stay and in-hospital stay, and late survival.

Statistical analysis

Statistical analysis was performed with SPSS statistical software (version 20, IBM SPSS Inc., Chicago, IL). Continuous data are reported as mean with standard deviation. Nominal variables are reported as counts and percentages. Differences between study groups were evaluated by the Mann–Whitney test, the Kruskal–Wallis test, the Chi square test, and Fisher's exact test. Long-term overall survival was assessed by the Kaplan–Meier and Cox proportional hazards methods.

The analysis of treatment methods in this series was expected to be biased by the inclusion of patients with highly heterogeneous baseline characteristics. This is particularly true for patients who underwent conservative treatment and endoscopic repair with endclips, as some of them had a small esophageal perforation with limited or no contamination of the surrounding field, whereas others were deemed unfit for any invasive treatment. Because of these heterogeneities, any further analysis was limited to comparison of the outcome of stent-grafting versus surgical repair. These two treatment groups were likely to differ markedly with respect to pre-treatment co-variables. Therefore, such differences between the study groups were accounted for by developing a propensity score for the treatment method. Propensity score analysis was used to control for all known patient factors that might be related to the decision to perform stent-grafting or surgical treatment of esophageal perforation, and thus potentially the outcome of interest. Propensity score was estimated only for stent-grafting versus surgical treatment. The propensity score was calculated by logistic regression with backward selection by including clinical variables with a p value <0.20 in univariate analysis. The calculated propensity score was employed only for adjustment of the risk in the overall series, because the relatively small number of patients included in this series prevented propensity score matching and stratification analyses.

Predictors of 30-day and/or in-hospital mortality were identified by logistic regression with backward selection including only variables with a p value <0.2 in univariate analysis. Classification tree analysis was performed by the Chi square automatic interaction detection (CHAID) method for classification of the risk for 30-day and/or in-hospital mortality according to the baseline and operative variables. Validation of the classification tree procedure was assessed by cross-validation through 25 folds. The minimum number of patients for the parent node was set to 20 and the minimum for the child node was 10. The maximum classification tree depth was 5. Receiver operating characteristics (ROC) curve analysis was employed for estimating of the area under the curve (AUC) of probabilities of regression models in order to assess the ability of these models in predicting 30-day and/or in-hospital mortality. A p value <0.05 was considered statistically significant.

Results

Baseline characteristics of the 194 patients treated for esophageal perforation are summarized in Table 1. This patient population had a rather high prevalence of renal failure (among 166 patients with available data, the estimated glomerular filtration rate [eGFR] < 60 ml/min/1.73 m^2: 29.5 %) and coronary artery disease (19.6 %). A large number of patients had coexistent benign (43.7 %) or malignant disease (10.3 %) of the esophagus or gastroesophageal junction. Initial treatment was initiated more than 24 h from the start of symptoms in 40 % of the patients. These four study groups significantly differed in the size (data available in 127 patients), cause, and site of perforation (Table 1). Among patients who underwent conservative treatment, one refused surgical repair and three were deemed unfit for surgery. Detailed data on primary and secondary procedures are reported in Table 2.

Results in the overall series

Thirty-four patients (17.5 %) died during the in-hospital and/or 30-day postoperative period. The rate of early survival with salvaged esophagus was 68.0 %. The mean length of stay in the intensive care unit (ICU) was 7 ± 12 days (median 2.0, range 0–90), and the hospital stay was 26 ± 21 days (median 21.0 days; range 1–114 days). The other outcome endpoints are summarized in Table 3. Overall survival at 1 year was 70.5 % (at risk 96 patients), and at 3 years it was 67.1 % (at risk 63 patients).

Univariate analysis showed that increased age (>70 years old: 29.5 % vs. <70 years old 9.5 %, $p < 0.0001$), eGFR < 60 ml/min/1.73 m^2 (32.7 vs. 12.0 %; $p = 0.002$), presence of coronary artery disease (42.1 vs. 11.5 %; $p < 0.0001$), sepsis (33.3 vs. 14.6 %; $p = 0.014$), and esophageal malignancy (40.0 vs. 14.9 %; $p = 0.005$) were associated with increased risk of in-hospital and/or 30-day mortality. Treatment delay > 24 h tended toward higher risk of mortality (22.7 vs. 12.4 %; $p = 0.067$).

Treatment method did not affect early mortality, but surgical repair was associated with somewhat lower mortality (Table 3). Among patients who underwent primary surgery, in-hospital and/or 30-day mortality was 7.1 % after esophagectomy/esophagogastrectomy (2 out of 28 patients), 14.6 % after primary repair (6 of 41 patients), 33.3 % after repair on drain (2 of 6 patients), and zero after simple coverage with a flap (0 of 5 patients) ($p = 0.261$).

Logistic regression showed that age ($p = 0.004$, OR 1.050, 95 % CI 1.015–1.085), coronary artery disease ($p = 0.008$, OR 3.406, 95 % CI 1.374–8.440), and esophageal malignancy ($p = 0.005$, OR 4.913, 95 % CI 1.610–14.994) were independent predictors of in-hospital and/or 30-day mortality (Hosmer–Lemeshow test: $p = 0.702$, area under the ROC curve 0.802, 95 % CI 0.728–0.876). Treatment method did not affect early mortality.

CHAID analysis (area under the ROC curve 0.799, 95 % CI 0.715–0.882) showed that coronary artery disease was the most powerful predictor of in-hospital and/or 30-day mortality (Fig. 1). Patients younger than 70 years of age without coronary artery disease, and without esophageal malignancy, had the lowest in-hospital and/or 30-day mortality (4.1 %).

Stent-grafting versus surgical treatment

Immediate results after bothstent-grafting and surgical repair are summarized in Table 3. The prevalence of stent-grafting varied markedly between participating centers (from 1.6 to 41.3 %; $p < 0.0001$). Only one center reported

Table 1 Baseline characteristics of patients with esophageal perforation according to the treatment strategy

Variable	Overall series 194 patients	Conservative treatment 43 patients	Endoclips 4 patients	Stent-grafting 63 patients	Surgical treatment 84 patients	*p* Value between study groups
Mean age (years)	62.7 ± 17.6	60.0 ± 22.0	61.5 ± 21.8	64.9 ± 15.9	62.5 ± 16.2	0.745
Median age (years)	65.2 (7.5–93.4)	63.1 (7.5–93.4)	61.0 (35.5–88.8)	66.7 (20.6–88.3)	63.1 (21.7–86.2)	
Female gender	116 (59.8)	20 (46.5)	2 (50.0)	43 (68.3)	51 (60.0)	0.156
Diabetes	14 (7.2)	3 (7.0)	0	4 (6.3)	7 (8.3)	0.910
Stroke	8 (4.1)	2 (4.7)	0	4 (6.3)	2 (2.4)	0.659
Coronary artery disease	38 (19.6)	11 (25.6)	1 (25.0)	9 (14.3)	17 (20.2)	0.532
Alcoholism	22 (11.5)	6 (14.3)	0	7 (11.1)	9 (10.8)	0.829
Benign esophageal disease	83 (43.7)	16 (38.1)	3 (75.0)	23 (34.4)	43 (51.8)	0.090
Malignant esophageal disease	20 (10.3)	6 (14.0)	0	10 (15.9)	4 (4.8)	0.112
eGFR < 60 ml/min per 1.73 m^2 (166 patients	49 (29.5)	11 (32.4)	0	20 (35.1)	18 (25.4)	0.355
Mean size of perforation, mm (135 patients)	24 ± 26	20 ± 24	7.5 ± 2.1	21 ± 26	27 ± 27	0.024
Median size of perforation, mm (135 patients)	15 (2–150)	13 (2–100)	8 (5–10)	13 (3–150)	20 (3–150)	0.024
Delay in treatment > 24 h (187 patients)	75 (40.1)	21 (56.8)	0	22 (34.9)	32 (38.6)	0.052
Sepsis	30 (16.0)	4 (10.0)	0	9 (14.3)	17 (21.3)	0.308
Cause of perforation						0.029
Boerhaave's syndrome	51 (26.3)	4 (9.3)	1 (25.0)	22 (34.9)	24 (28.6)	
Other spontaneous perforation	28 (14.4)	11 (25.6)	0	6 (9.5)	11 (13.1)	
Iatrogenic perforation (endoscopy)	69 (35.6)	18 (41.9)	1 (25.0)	22 (34.9)	28 (33.3)	
Iatrogenic perforation (other procedures)	26 (13.4)	2 (4.7)	2 (50.0)	9 (14.3)	13 (15.5)	
Traumatic	4 (2.19	1 (2.3)	0	1 (1.6)	2 (2.4)	
Foreign body	12 (6.2)	7 (16.3)	0	2 (3.2)	3 (3.6)	
Caustic injury	4 (2.1)	0 (0)	0	1 (1.6)	3 (3.6)	
Traumatic injury to other organs	6 (4.3)	1 (2.9)	0	1 (2.7)	4 (6.3)	0.755
Site of perforation						0.007
Cervical	20 (10.4)	9 (22.0)	0	1 (1.6)	10 (11.9)	
Cervicothoracic	10 (5.2)	1 (2.4)	0	4 (4.8)	5 (6.0)	
Intrathoracic	82 (42.7)	20 (48.8)	1 (25.0)	22 (34.9)	39 (46.4)	
Thoracoabdominal	65 (33.9)	9 (22.0)	2 (50.0)	35 (52.4)	21 (25.0)	
Intra-abdominal	15 (7.8)	2 (4.9)	1 (15.0)	3 (4.8)	9 (10.7)	

Continuous data are reported as mean with standard deviation and as median and range; dichotomous and nominal variables are reported as absolute number and percentage

eGFR estimated glomerular filtration rate

on stent-grafting as a primary procedure in more than 20 patients and achieved a 30-day and/or in-hospital mortality rate of 7.7 % (2 out of 26 patients) and an early survival with salvaged esophagus of 92.3 %.

Univariate analysis showed that stent-grafting was associated with 30-day and/or in-hospital mortality similar to that of surgical repair (19.0 vs. 13.1 %; $p = 0.326$), as well as similar rates in the other secondary outcome end-points. Stent-grafting was associated with significantly higher early survival with salvaged esophagus (77.8 vs. 56.0 %; $p = 0.006$). Patients undergoing stent-grafting significantly differed from those undergoing surgical repair in terms of associated benign ($p = 0.043$) or malignant ($p = 0.023$) diseases of the esophagus or gastroesophageal tract, as well as size ($p = 0.038$) and site of perforation ($p = 0.004$). However, other subtle baseline differences

Table 2 Data on primary and repeat procedures for treatment of esophageal perforation according to the treatment strategy

Variable	Overall series 194 patients	Conservative treatment 43 patients	Endoclips 4 patients	Stent-grafting 63 patients	Surgical treatment 84 patients
Primary major procedures					
Primary repair	41 (21.1)	–		–	41 (51.3)
Esophagectomy with or without reconstruction	22 (11.3)	–		–	22 (27.5)
Esophagogastrectomy with or without reconstruction	6 (3.1)	–		–	6 (7.5)
Repair on drain	6 (3.1)	–		–	6 (7.5)
Coverage with flap	5 (2.6)	–		–	5 (6.3)
Primary minor surgical procedures					
Cervical debridement/drainage	11 (10.8)	3 (6.9)	1 (25.0)	3 (4.8)	14 (16.7)
Simply pleural drainage	49 (25.3)	7 (16.3)	0	19 (30.2)	22 (26.2)
Thoracoscopic pleural debridement/decortication	12 (6.2)	2 (4.6)	1 (25.0)	8 (12.7)	2 (2.3)
Thoracotomy and pleural debridement/decortication	34 (17.5)	2 (4.6)	0	8 (12.7)	24 (28.6)
Thoracostomy	5 (2.6)	0	0	1 (1.7)	3 (3.4)
Laparoscopy/laparotomy	8 (4.1)	0	0	4 (6.3)	4 (4.6)
Procedures after primary treatment					
Further thoracotomies/thoracoscopies after primary treatment					
Conversion to surgical repair	11 (5.7)	1 (2.3)	0	10 (15.2)	–
Conversion to stent-grafting or surgical repair	3 (1.5)	3 (6.8)	0	–	–
Conversion from surgery to stent-grafting	4 (2.0)	–	–	–	4 (4.8)
Repeat stent-grafting	13 (6.7)	–	–	13 (19.7)	–
Stent-graft repositioning	10 (5.2)	–	–	10 (16.7)	–
Any esophagectomy/esophageal exclusion	33 (17.0)	1 (2.3)	0	2 (3.2)	30 (35.7)

Dichotomous and nominal variables are reported as absolute number and percentage

existed between these two patients groups (Table 1). The obtained propensity score had an area under the ROC curve of 0.750 (95 % CI 0.669–0.831; Hosmer–Lemeshow test: $p = 0.208$). When adjusted for propensity score, stent-grafting achieved a 30-day and/or in-hospital mortality ($p = 0.946$) similar to that achieved with surgical treatment. Similar results were obtained when treating center was included in the multivariate analysis. Propensity score adjusted analysis confirmed that stent-grafting was associated with a significantly higher rate of survival with salvaged esophagus ($p = 0.001$, OR 0.253, 95 % CI 0.110–0.585). No significant differences were observed in the other outcome endpoints.

Stent-grafting versus primary surgical repair

Primary surgical repair was associated with somewhat lower 30-day and/or in-hospital mortality than stent-grafting (14.6 vs. 19.0 %; $p = 0.561$). Similar rates of late esophagectomy were observed after primary surgical repair and stent-grafting (4.9 vs. 3.2 %). Survival with salvage esophagus was 85.4 % after primary repair and 77.8 % after stent-grafting ($p = 0.337$).

After patients with associated esophageal cancer were excluded, primary surgical repair was still associated with somewhat better 30-day/in-hospital mortality (10.3 vs. 15.1 %; $p = 0.496$) and survival with salvaged esophagus (89.7 vs. 81.1 %; $p = 0.256$).

Discussion

No treatment strategy has thus far been shown to be superior to all others in the management of esophageal perforation. This can be explained in part by the heterogeneous causes of esophageal perforation, the timing of diagnosis and treatment, and the severity of esophageal

Table 3 Outcome after esophageal perforation according to the treatment strategy

Variable	Overall series 194 patients	Conservative treatment 43 patients	Endoclips 4 patients	Stent-grafting 63 patients	Surgical treatment 84 patients	*p* value between study groups
30-day or in-hospital mortality	34 (17.5)	10 (23.3)	1 (25.0)	12 (19.0)	11 (13.1)	0.499
30-day mortality	30 (15.5)	10 (23.3)	0	10 (15.9)	10 (11.9)	0.314
Early survival with salvaged esophagus	132 (68.0)	33 (76.7)	3 (75.0)	49 (77.8)	47 (56.0)	0.019
Mean ICU stay, days	7.3 ± 12.3	2.5 ± 7.7	10.8 ± 18.9	5.9 ± 8.8	10.5 ± 15.0	<0.0001
Median ICU stay, days	20 (0–90)	0 (0–40)	2 (0–39)	2.0 (0–38)	5.0 (0–90)	
Mean in-hospital stay, days	26 ± 21	17.3 ± 14.2	37.3 ± 14.2	28.7 ± 24.3	27.2 ± 20.0	0.003
Median in-hospital stay, days	21.0 (1–114)	13.0 (1–63)	32 (27–58)	21.0 (3–114)	22.5 (1–102)	
Reoperation for bleeding	3 (1.5)	0	0	1 (2.4)	2 82.4)	0.771
Renal replacement therapy	3 (1.5)	1 (2.3)	0	0	2 (2.4)	0.658
Stroke	0	0	0	0	0	–
Myocardial infarction	7 (3.6)	1 (2.3)	0	1 (1.6)	5 (6.0)	0.490
Sepsis	41 (21.1)	10 (23.3)	1 (25.0)	11 (17.5)	19 (22.6)	0.856

Continuous data are reported as mean with standard deviation and as median and range; dichotomous and nominal variables are reported as absolute number and percentage

ICU intensive care unit

rupture and the extent of its related local and systemic complications. Patients' comorbidities also may have a significant prognostic role, but they have not been adequately investigated. The use of nonspecific critical care scores has been shown to be of value in stratifying the risk of these patients, but their complexity prevents their use at the bedside [7].

Along with the relatively low incidence of this condition, heterogeneity of patients' condition and nature of esophageal perforation make difficult for any approach to adequately stratify their risk and compare different treatment strategies. To date, most reports have attempted only to report the results of institutional series to demonstrate the efficacy of treatment strategies developed by surgeons dedicated to the management of this severe condition, but those reports have failed to provide data on comparative analyses. Data on the extent of perforation and the status of the esophagus are of importance in the decision-making process—i.e., whether local repair or esophagectomy should be performed—and the lack of such data introduces a bias in the evaluation of repair approaches. As a consequence, there is lack of conclusive data on the relative efficacy of any of available treatment methods.

A recent meta-analysis summarized the results of current treatment strategies as well as the prognostic impact of baseline characteristics [2]. The present study showed that pooled immediate mortality after esophageal perforation was 11.9 % [2]. However, this figure can be much higher, as published studies possibly were not from unselected series including consecutive, all-comers patients like in this multicenter study. In fact, results from series with higher mortality rates might have gone unreported. Furthermore, perforations diagnosed at autopsy are also not reported [8]. Most importantly, major pitfalls in reporting baseline characteristics, treatment modalities, and outcome of these patients may further complicate the analysis and interpretation of published studies [6]. Such pitfalls, along with the scattered reports of small numbers of patients, may represent a major barrier to the understanding of this severe emergency condition and evaluation of the results of different treatment strategies. In fact, experience of single institutions can be limited as we estimated a pooled mean rate of esophageal perforation of 3.9 cases per year (range 1.1–11.9 cases) [2]. Consequently, better quality data from larger unselected series from multiple centers may be helpful in the evaluation of prognosis of these patients and interpretation of the results of different treatment modalities.

This multicenter study was planned to collect and evaluate a large number of patients from tertiary referral centers with detailed baseline and operative data in order to evaluate the current outcome of esophageal perforation with focus on comparing the results of stent-grafting and surgical repair. We aimed also to retrieve data on variables previously not thoroughly assessed, such as location and size of perforation as well as several other baseline

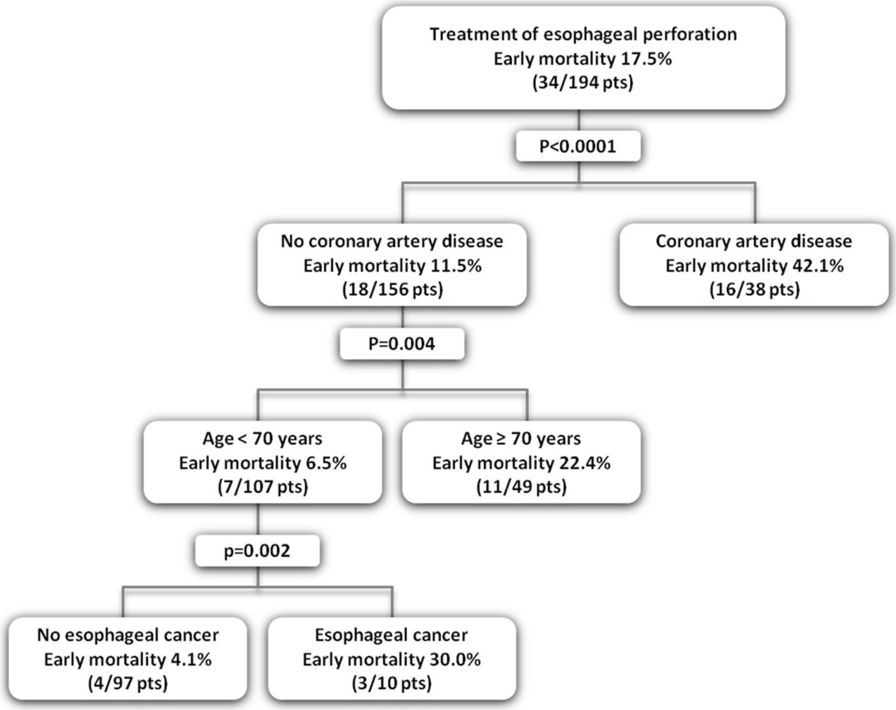

Fig. 1 Chi squared automatic interaction detection (CHAID) tree showing the impact of different variables on the outcome of esophageal perforation. Adjusted *p* values are given at each node split

comorbidities. This study also assessed all minor procedures needed to assist the success of these treatment methods, along with a number of immediate postoperative outcome endpoints, as well as survival with salvaged esophagus and late survival. This attempt shed light on the complexity of the assessment of the operative risk as well as the outcome of this severe condition. The heterogeneity of baseline characteristics and treatment approaches is a major confounder and might have prevented conclusive results in this study, which is the largest detailed series on esophageal perforation. Still, this series is not large enough to reliably assess the real efficacy of any single treatment method in relation to esophageal perforations of different characteristics in patients with different comorbidities. In fact, sample size calculation indicates that in order to detect a significant decrease in early mortality from 13.1 %, as observed in the present surgical series, to 7.7 % of stent-grafting, as observed in one of these centers, we would need 501 patients in each study group ($\alpha = 0.05$, power = 0.80). Such a large number of patients is unlikely to be recruited either prospectively or retrospectively. Therefore, the end-point of clinical relevance, such as survival with salvaged esophagus, can be a valid parameter with which to evaluate the efficacy of any new treatment method for esophageal perforation. In fact, the required sample size to validate the difference in terms of survival with salvage esophagus between surgery and stent-grafting as herein observed would be 72 patients in each study group.

Despite these limitations, this unselected series from multiple centers showed that early mortality in patients treated for esophageal perforation is significant and even higher than that of a recent pooled analysis [2]. The high risk of these patients was confirmed by their suboptimal 3-year survival.

Contrary to other studies [9], any direct attempt to repair the esophageal tear was associated with a better outcome than conservative treatment. However, we recognize that a conservative approach can still be indicated for small perforations without signs of contamination or for a number of lesions involving the cervical esophagus. The main finding of this study is that stent-grafting had a somewhat higher rate of early mortality as compared with surgery, but that it achieved a significantly higher survival rate with salvaged esophagus. This was observed despite the higher prevalence of esophageal malignancy among patients undergoing stent-grating. Indeed, esophagus salvage is a major achievement in patients with esophageal perforation and is most likely associated with improved quality of life. This finding also suggests that stent-grafting is an effective esophagus-sparing treatment, but further experience is needed to demonstrate its beneficial effects in reducing operative mortality.

Even if this series did not provide evidence of the goodness of this minimally invasive treatment, the results of a participating center with a large experience in esophageal stent-grafting are encouraging (early mortality 7.7 %) and suggest that increasing experience with endoluminal repair may be a key factor in improved results. In fact, the high number of repeated thoracotomies/ thoracoscopies, as well as the significant number of repeat stenting and repositioning, suggests that stent-grafting very often requires further procedures to effectively exclude leakage from the site of esophageal rupture and to treat surrounding contaminated tissues. Indeed, concomitant and later minor procedure such as thoracoscopies and thoracotomies must be viewed as methods to assist the success of stent-grafting and not as adverse events.

In the center with the largest experience with esophageal stent-grafting, contamination is aggressively treated by thoracoscopy at the time of stenting, as well as later on. The aim is to control infection and seal the perforation site in an attempt at esophageal salvage. This in turn means that effective stent-grafting requires adequate expertise and certainly also further technical development.

The results of this study confirm the complexity of treatment of esophageal perforations. Because of the lack of evidence of the superiority of any treatment method over all others, the strategy to cure this severe disease should continue to be based on a judicious clinical decision-making process. Indeed, in the present study we observed that stent-grafting is not a panacea in the management of this severe condition and that an extensive procedure such as esophagectomy may still achieve early survival rate higher than 90 %. Therefore our study confirms that stent-grafting has the potential of effectively preserving the esophagus, but it is likely that surgical expertise is a key factor in decreasing the current high mortality rate. The way to demonstrate the beneficial effect of less invasive treatments for esophageal perforation seems to be long and perilous.

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