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Retrospective Study

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Perioperative Factors Associated with Tracheostomy use following Esophagectomy Surgery

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Abstract

Background: Esophagectomy surgery remains high risk with 36% of patients in the UK having a complication. Tracheostomy insertion can aid weaning from ventilation post-operatively and can be inserted at the time of surgery (elective) or post-operatively (delayed). We aimed to identify factors associated with elective and delayed tracheostomies, as well as differences in outcomes in each group.

Methods: We retrospectively reviewed cases over a 5-year period.

Results: During this period 98 patients did not require a tracheostomy after esophagectomy surgery, 36 had an elective tracheostomy inserted and 23 required a delayed tracheostomy. An increased ASA (3-4), being a current or ex-smoker and an increased BMI were independent factors for having an elective tracheotomy inserted. An increased BMI was an independent risk factor for requiring a delayed tracheostomy. Patients with delayed tracheostomies had the longest ICU and hospital stay followed by the elective group. The 'no tracheostomy' group had the shortest ICU and hospital length of stay. There were no differences in mortality between the groups.

Conclusion: Patients who require a delayed tracheostomy after oesophageal surgery have longer ICU and hospital length of stay. This study demonstrates an association between an increased BMI and the need for a delayed tracheostomy. Patients with an increased BMI may benefit from the insertion of an elective tracheostomy on the day of surgery.

Keywords

Esophagectomy, Tracheostomy, Postoperative period, Respiratory insufficiency

Introduction

Esophagectomy is a major oncological surgical procedure, associated with significant morbidity and mortality [1,2]. In the United Kingdom (UK), there is a 16.9% respiratory complication rate with 36.4% of patients having some sort of complication. Thirty-day mortality is 1.9% and 90 day mortality 3.3% [2].

After esophagectomy, where feasible at our institution we aim to extubate on the day of surgery. A certain percentage of these patients will end up requiring a tracheostomy for a variety of medical and surgical reasons. However, in certain cases, such as patients with difficulty with oxygenation intra-operatively, complicated and prolonged surgery, severe lung disease or high inotrope requirements, it is not possible to extubate on the day of surgery [3-5]. In these cases, elective tracheostomy insertion at the completion of the esophagectomy is considered in our institution.

Tracheostomy insertion has several possible advantages over translaryngeal intubation. This includes improved access to the tracheobronchial tree for suctioning, oral hygiene and pulmonary toilet. Tracheostomy can increase patient comfort and decrease levels of sedation and their resultant side

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effects such as need for inotropic support. The patient can potentially be weaned from the ventilator more rapidly [6-8]. There is some evidence that in the general ICU patient early tracheostomy insertion improves mortality versus late insertion however this is debated in the ICU literature [8-11]. Approximately 20% of Upper Gastro Intestinal surgeons in the UK who responded to a survey had sited or asked a colleague to site an elective tracheostomy [12].

There is limited published evidence regarding tracheostomy use in esophagectomy patients. Wessels, et al. showed a decreased length of mechanical ventilation, decreased length of ICU and hospital stay in patients in our institution who had an elective tracheostomy compared to a delayed tracheostomy [13].

Sakatoku, et al. found no difference in rates of pneumonia, atelectasis, hospital length of stay or 90-day mortality between high risk patients who had an elective prophylactic mini tracheostomy inserted and those who were not high risk and had no tracheostomy inserted. In their study, patients were considered high risk if they were over 80 years of age, had reduced pulmonary function (Forced expired volume in 1 second (FEV1) < 1.5 L or predicted FEV1 < 60%), pneumonia, or aspiration noted on upper gastro intestinal imaging or had evidence of a vocal palsy on bronchoscopy after extubation. FEV1.0% < 70% and vocal cord palsy were independent risk factors for requiring a delayed mini tracheostomy [14].

Tracheostomy insertion is not without risk. These risks can be divided into immediate risks such as hemorrhage or pneumothorax, short term risks such as blockage or tube displacement and long-term risks such as tracheal stenosis and tracheocutaneous fistula [15,16]. The definition and rates of complications vary in the published literature with an overall range of complications of 2.1 to 23% [17]. Rates of complications reported include minor bleeding 4.3-12.5% [17,18], major bleeding 1.5-5% [17], pneumothorax 0.5-1.6% [17,19-21] and blockage or obstruction 0.46- 6.5% [17,21,22]. Long term complications include tracheoesophageal fistula with a risk of less than 1% [19,23] and tracheal stenosis 0.35-3.7% [18,23,24]. These potential complications of tracheostomy insertion need to be weighed up against potential benefits.

Currently, the decision to insert a tracheostomy in our institution is a result of a discussion between the anesthetic and surgical teams based on pre-morbid factors and the perceived surgical complexity. Patients are fully consented to the risks associated with elective tracheostomy as part of the preoperative general consenting process.

We defined “elective” tracheostomy as tracheostomy insertion intraoperatively and “delayed” as insertion during the post-operative period. Both the elective and tracheostomy groups had sedation weaned post insertion when clinically appropriate.

Our primary aim was to analyze the factors which are associated with use of elective tracheostomy in our patient population. We also aimed to compare outcomes in the 3 patient groups: No tracheostomy, elective tracheostomy and delayed tracheostomy. We included factors associated with increased morbidity or mortality as well as adverse short-term outcomes [25-30].

Methods

We conducted a retrospective observational analysis of patients undergoing esophagectomies at the Royal Marsden over 5-years between September 2010 and December 2015. This study was approved by the hospital Committee for Clinical Research.

Statistical analysis

Descriptive analysis method was used to summarize the variables in the tracheostomy groups using counts and percentages and mean/median and standard deviation/range as appropriate. Multinomial logistic regression analysis method was used to determine factors/variables that predict patients’ allocation to the elective, delayed and no tracheostomy groups.

Patients’ ICU length of stay, total hospital length of stay and total ventilation hours were compared between the 3 groups using Analysis of variance (ANOVA) or Kruskal-Wallis’ non-parametric method as appropriate.

Rates of mortality at 30 days and at 1 year, readmission to ICU, renal, cardiovascular, neurological, wound, return to theatre, infectious complication were assessed between the groups using binary logistic regression. Details on the number and percentages, odds ratios and 95% confidence interval were reported.

Receiver operator characteristics curves were used to determine the best BMI cut off point that discriminated between the need for each of elective and delayed tracheostomies.

The sample size and duration of the study was chosen based on the ability to have the most complete data set from the time of the commencement of electronic anesthetic records.

Results

A total of 157 patients underwent esophagectomy surgery. Of those 98 did not require tracheostomies, 36 had an elective tracheostomy and 23 a delayed tracheostomy. Baseline data is summarized in Table 1. There were no differences in age or gender, tumor staging, neoadjuvant chemotherapy, pulmonary function (FEV1), forced vital capacity (FVC), max work performed on cardiopulmonary exercise testing (CPET), laparoscopic assisted versus open technique, intraoperative fluid given or blood loss between the groups. There were differences in ASA status, APACHE 2 score and possum score, as well as BMI, smoking status, anaerobic threshold (AT) and maximum oxygen consumption (VO2 max) on CPET and complexity of surgery (2 stage versus 3 stage and duration). These differences are further quantified in the univariate and multivariate analysis below.

Univariate analysis

Patients who had an elective tracheostomy when compared to the no tracheostomy group had higher ASA scores (RRR = 6.64 (2.86-15.40), $p < 0.001$), worse POSSUM (RRR 1.11 (1.02-1.20), $p = 0.014$) and APACHE 2 scores (RRR 1.15 (1.06-

Table 1: Baseline characteristics of no tracheostomy, elective tracheostomy and delayed tracheostomy groups.

	No tracheostomy	Elective tracheostomy	Delayed tracheostomy	P value
Patients *number*	98	36	23	
Age (years) *Mean (SD)*	62.62 (9.64)	64.11 (9.51)	60.30 (9.37)	0.333
Male *n (%)*	83 (85)	32 (89)	21 (92)	0.635
ASA 1-2 **ASA 3-4** *n (%)*	73 (74) 25 (26)	11 (31) 25 (69)	13 (57) 10 (43)	< 0.001
APACHE II *Mean (SD)*	16.45 (4.81)	20.09 (5.23)	18.19 (5.46)	0.001
BMI *Mean (SD)*	26.54 (4.00)	29.21 (7.04)	30.12 (5.08)	0.002
Non-smoker **Ex-smoker** **Current smoker** *n (%)*	41 (42) 50 (51) 7 (7)	2 (6) 27 (75) 7 (19)	8 (35) 12 (52) 3 (13)	0.002
Nodes negative **Nodes positive** *n (%)*	52 (54) 44 (46)	23 (66) 12 (34)	10 (43) 13 (57)	0.236
Neoadjuvant chemotherapy *n (%)*	77 (79)	29 (81)	17 (74)	0.600
Completed neoadjuvant chemotherapy *n (%)*	71 (72)	25 (69)	17 (74)	0.337
Preoperative POSSUMP *Median (IQR)*	19 (15-22)	21 (18-25)	16 (14-21)	0.035
FEV1 (liter) + *mean (SD)*	3.21 (0.68)	3.07 (1.03)	2.69 (0.69)	0.207
FVC (liter) + *mean (SD)*	4.29 (0.97)	4.05 (0.98)	3.67 (0.72)	0.170
Anaerobic threshold (AT)* VO_2 (ml/kg/min) *mean (SD)*	12.17 (3.06)	10.65 (2.51)	11.26 (2.00)	0.043
VO_2-Max (ml/kg/min)* *mean (SD)*	19.10 (4.32)	16.83 (3.48)	17.01 (3.71)	0.023
AT work (Watts)* *mean (SD)*	71.84 (27.94)	64.60 (30.51)	69.24 (22.26)	0.533
Lap-assisted **Open** *n (%)*	49 (50) 49(50)	16 (44) 20 (56)	8 (35) 15 (65)	0.404
2 Stage **3 Stage** *n (%)*	97 (99) 1 (1)	31 (86) 5 (14)	23 (100) 0	0.006
Duration surgery **(Minutes)** *Median (IQR)*	399 (73)	475 (64)	434 (98)	<0.001
Intraoperative fluid (liter) *Median (SD)*	2.96 (1.55)	3.50 (1.06)	2.90 (1.40)	0.131

Estimated blood loss (ml) *Median (IQR)*	500 (300-755)	450 (300-550)	546 (400-682)	0.711

*Not all patients underwent cardiopulmonary exercise testing. Numbers were: no tracheostomy 57/98, elective tracheostomy 30/36 and Delayed tracheostomy 18/23.

+Not all patients underwent pulmonary function testing. Numbers were: No tracheostomy 49/98, elective tracheostomy 27/36 and delayed tracheostomy 9/23.

SD: Standard deviation; n: Number; ASA: American Society of Anesthesiologists physical status classification system; APACHE: Acute Physiology and Chronic Health Evaluation; BMI: Body Mass Index; POSSUM P: Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity Portsmouth; IQR: Interquartile Range; FEV1: Forced Expiratory Volume in one second; FVC: Forced Vital Capacity; AT: Anaerobic Threshold; ml/kg/min: milliliters per kilogram per minute; VO_2 max: Maximal oxygen consumption.

Table 2: Univariate analysis of peri-operative factors associated with having an elective or delayed tracheostomy.

	No vs. elective		**No vs. delayed**	
	RRR (95% CI)	P value	RRR (95% CI)	P value
ASA 1 - 2	1		1	
ASA 3 - 4	6.64 (2.86-15.40)	< 0.001	2.25 (0.88-5.76)	0.092
APACHE II	1.15 (1.06-1.25)	0.001	1.08 (0.98-1.19)	0.142
POSSUMP	1.11 (1.02-1.20)	0.014	0.95 (0.84-1.07)	0.398
BMI	1.12 (1.03-1.21)	0.008	1.15 (1.05-1.27)	0.003
Smoking status:				
Non-smoker	1		1	
Ex-smoker	10.8 (2.42-48.17)	0.002	1.2 (0.45-3.22)	0.717
Current smoker	20.0 (3.42-116.8)	0.001	2.14 (0.45-10.11)	0.335
AT	0.78 (0.64-0.96)	0.019	0.86 (0.69-1.08)	0.189
VO2-Max	0.86 (0.75-0.97)	0.018	0.87 (0.74-1.02)	0.075
Surgical stage				
Stage 2	1	0.014	-	-
Stage 3	15.63 (1.76-138.9)			
Duration of surgery	1.01 (1.01-1.02)	< 0.001	1.01 (1.00-1.01)	0.048

RRR: Relative Risk Ratio; ASA: American Society of Anesthesiologists physical status classification system; APACHE: Acute Physiology and Chronic Health Evaluation; BMI: Body Mass Index; POSSUM P: Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity, Portsmouth; AT: Anaerobic Threshold; VO_2 max: Maximal oxygen consumption.

1.25) p = 0.001) and had higher BMIs (RRR 1.12 (1.03-1.21) p = 0.008). They were more likely to be ex or current smokers (RRR 10.8 (2.42-48.17) p = 0.002 and RRR 20.0 (3.42-116.8) p = 0.001 respectively) and had a lower anaerobic threshold (RRR 0.78 (0.64-0.96 p = 0.019) and VO2 max (RRR 0.86 (0.75-0.97) p = 0.018). More had 3 stage procedures (RRR 15.63(1.76-138.9) p = 0.014) and their surgery was longer (RRR 1.01 (1.01-1.02), p < 0.001). Patients who required a delayed tracheostomy had higher BMIs (RRR 1.15 (1.05-1.27) p = 0.003) and longer duration of surgery (RRR 1.01 (1.00-1.01) p = 0.048) than those who did not require a tracheostomy. See Table 2 for further details.

Multivariate analysis

Factors which continued to be significant with multivariate analysis in the elective tracheostomy group versus no tracheostomy group were ASA (RRR 7.12 (2.75-18.39), p < 0.001), Smoking status (ex RRR 10.05 (2.08-48.54) p = 0.013 and current RRR 27.24 (3.86-192.32) p = 0.004) and BMI (RRR 1.14 (1.03-1.26), p = 0.015). BMI was also significant when comparing delayed versus the no tracheostomy group (RRR 1.20 (1.08-1.34) p = 0.001). See Table 3 for further details.

Outcome data

Patients who did not require a tracheostomy had the shortest ICU and hospital stay (median 6 and 14 days respectively). Patients who had an elective tracheostomy had a median ICU stay of 10 days and hospital stay of 14 days. Patients who required a delayed tracheostomy had the longest ICU and hospital stay (median 19 and 27 days respectively; p < 0.001). Patients with a delayed tracheostomy had the longest number of hours ventilated (median 336 hours), followed by the elective tracheostomy group (median 166 hours). The no tracheostomy group required ventilation for the shortest time (median 17 hours; p < 0.001). See Table 4 for further details.

Table 3: Multivariate analysis of peri-operative factors associated with having an elective or delayed tracheostomy.

	No vs. Elective		**No vs. Delayed**	
Variable	**RRR (95% CI)**	**p-value**	**RRR (95% CI)**	**p-value**
ASA:				
1 - 2	1	< 0.001	1	0.115
3 - 4	7.12 (2.75-18.39)		2.25 (0.82-6.19)	
BMI	1.14 (1.03-1.26)	0.015	1.20 (1.08-1.34)	0.001
Smoking status:				
Non-smoker	1		1	
Ex-smoker	10.05 (2.08-48.54)	0.013	0.88 (0.30-2.61)	0.823
Current smoker	27.24 (3.86-192.32)	0.004	3.97 (0.73-21.41)	0.109

RRR: Relative Risk Ratio; CI: Confidence Interval; ASA: American Society of Anesthesiologists physical status classification system; BMI: Body Mass Index.

Table 4: ICU, hospital length of stay and ventilation duration in each tracheostomy group.

OUTCOME Variables	**No Tracheostomy**	**Elective Tracheostomy**	**Delayed Tracheostomy**	**p-value**
ICU stay (days): *Median (IQR)*	6 (5-8)	10 (8-14)	19 (14-27)	< 0.001
ICU stay – (Log days) *Mean (SD)*	1.85 (0.35)	2.40 (0.49)	2.96 (0.43)	< 0.001
Hospital stay - (days) *Median (IQR)*	14 (11-18)	14 (14-29)	27 (20-40)	< 0.001
Total ventilation hours: *Median (IQR)*	17 (2-32)	166 (123-286)	336 (216-504)	< 0.001

IQR: Interquartile Range.

Table 5: Pneumonia, surgical complications, return to theatre and mortality data for each tracheostomy group.

	Variables	**No** **n (%)**	**Yes** **n (%)**	**Odds Ratio (95% CI)**	p-value
Pneumonia	No	52 (53)	46 (47)	1	0.003
	Delayed	4 (17)	19 (83)	5.37 (1.70-16.94)	0.004
	Elective	11 (31)	25 (69)	2.57 (1.14-5.79)	0.023
Surgical complication	No	85 (87)	13 (13)	1	0.005
	Delayed	13 (57)	10 (43)	5.03 (1.83-13.81)	0.002
	Elective	31 (86)	5 (14)	1.05 (0.35-3.20)	0.925
Theatre return	No	92 (94)	6 (6)	1	0.036
	Delayed	18 (78)	5 (22)	4.26 (1.17-15.47)	0.028
	Elective	35 (97)	1 (3)	0.44 (0.05-3.77)	0.452
Mortality 30 days	No	96 (98)	2 (2)	1	
	Delayed	22 (96)	1 (4)	2.18 (0.19-25.15)	0.815
	Elective	35 (97)	1 (3)	1.37 (0.12-15.60)	
Mortality 1 year	No	94 (96)	4 (4)	1	
	Delayed	20 (87)	3 (13)	3.53 (0.73-16.99)	0.164
	Elective	35 (97)	1 (3)	0.67 (0.07-6.22)	

Post-hoc pairwise comparison p-values were adjusted by Bonferroni method for ICU, hospital stay and ventilation hours. Pairwise tests are significantly different for the ICU stay between all groups as well as for hospital stay and total ventilation hours between no tracheostomy versus both elective and delayed groups. However, this is not the case between the elective and delayed groups whose hospital stay and total ventilation hours showed no significant differences with p-values 0.116 and 0.448 respectively.

Ventilator acquired pneumonia was more common in both elective and delayed tracheostomy groups versus the no tracheostomy group ($p = 0.023$ and $p = 0.004$ respectively). There were more surgical complications and returns to theatre for the delayed versus no tracheostomy group ($p = 0.002$ and $p = 0.028$ respectively). There was no statistically significant difference in mortality rates at both 30 days and 1 year (see Table 5).

The indication for a delayed tracheostomy was often multifactorial but there was always a respiratory component including difficulty with ventilation, inability to clear secretions, pneumonia and likely long respiratory wean (see Supplementary Tables).

Receiver operator curves were used to quantify the increased BMI associated with both elective and delayed tracheostomies. For the elective group, a BMI of 27.8 had a sensitivity of 60% and specificity of 60%. For the delayed group, a BMI of 28.0 had a sensitivity of 74% and specificity of 62%.

Discussion

There is minimal published data regarding the use of peri-operative tracheostomies for patients undergoing an esophagectomy. In our institution, we aim to identify patients who are at increased risk of needing a post-operative tracheostomy and insert them early. In this study, we have showed that we inserted tracheostomies electively in patients with higher ASA scores, worse POSSUM and APACHE 2 scores, higher BMIs, ex or current smokers with lower anaerobic threshold and VO2 max and those undergoing longer surgery. These patients have a shorter ICU length of stay than those who have a delayed tracheostomy.

The only factor identified as having a significant difference between the no tracheostomy and delayed tracheostomy group is an increased BMI. Patients requiring a delayed tracheostomy have the longest ICU and hospital lengths of stay. In a recent meta-analysis comparing esophagectomy patients with a BMI of less than 30 to patients with a BMI equal to or greater than 30 showed patients with higher BMIs were at increased risk of anastomotic leak but had better 5-year survival. In this meta-analysis there was no difference found in pulmonary complications, reoperation, bleeding or early mortality [3].

There are a number of peri-operative factors that contribute to a patient requiring a delayed tracheostomy and this group had more surgical complications with a higher number needing to return to theatre. When the delayed tracheostomy cases are considered individually, however, they all had the tracheostomy inserted for respiratory indications and some patients with surgical complications did not require a tracheostomy.

Prior research found FEV 1.0% < 70% and vocal cord palsy were independent risk factors for requiring a delayed mini tracheostomy [7]. We did not specifically examine patients for vocal cord palsy but did not find FEV1 to be associated with delayed tracheostomies. This study was however not powered for this outcome and there was a trend towards a decreased FEV1 and FVC in patients requiring a delayed tracheotomy (RRR 0.45 (0.18-1.11) and 0.49 (0.22-1.09) respectively).

A strength of this study is that we systematically searched for all esophagectomies performed in a high-volume center over a 5-year period. As a quaternary referral hospital, we are often asked to do cases which are considered too high risk at other institutions which may contribute to the overall higher rates of tracheostomies in our population.

Although this research has many strengths, it has a number of limitations. Firstly, it is not a randomized controlled trial. It would however be difficult to perform a randomized controlled trial which is why this research is valuable.

We hypothesize that the return to baseline (no tracheostomy) in the high-risk tracheostomy group is due to the treatment effect of elective tracheostomy insertion however it is possible that the reason for no difference in some cases is that the elective tracheostomy made no difference in the patients' outcomes. In these cases, patients may not have needed a tracheostomy and thus exposing them to the risk of a tracheostomy. It is difficult to determine if this is the case in this retrospective analysis.

The delayed tracheostomy group did have a higher number of surgical complications. It is plausible that this contributed to a higher ICU hospital length of stay. Given this is not a randomized controlled trial, it is not possible to determine if the surgical complications led to the need for a tracheostomy.

Analgesia techniques were not specifically studied in this research project which is a weakness of this study. Patients had either an epidural inserted or intrathecal local anesthetic and morphine with a paravertebral catheter and a PCA.

The aim of this study was to identify factors associated with elective and delayed tracheotomies and compare outcomes. In this institution, we continue to insert elective tracheostomies, and the relatively high use (in comparison to other centers) reflects a combination of surgical complexity and patient morbidity as a tertiary/quaternary referral center. This research is unable to conclusively advocate the use of elective tracheostomy in high risk esophagectomy patients nor does it conclusively demonstrate that elective tracheostomies should not be used. As a randomized controlled trial would be difficult to perform, clinical judgement needs to be used. There are potential risks associated with tracheostomy insertion which must also be considered.

Conclusion

This study shows patients undergoing an elective tracheostomy in our institution were more likely to have higher

BMIs, to have smoked, to have had longer surgery and had a lower anaerobic threshold and VO2 max. The need for a delayed tracheostomy was associated with higher BMIs and a BMI of 28 had a sensitivity of 74% and specificity of 62% in this group. Patients who had a delayed tracheostomy had the longest ICU and hospital lengths of stay.

Authors Declaration

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Supplementary Tables

Table 6: Other baseline characteristics of each tracheostomy group.

	No tracheostomy	Elective tracheostomy	Delayed tracheostomy	P value
WHO PS				
0	45	13	9	0.419
1	47	16	11	
2	4	5	2	
3	2	1	1	
Pre-operative nutritional support *n (%)*	52 (53)	25 (69)	16 (70)	0.128
Peak flow (l/min) *Mean (SD)*	n = 78 477.18 (107.73)	n = 26 447.50 (148.04)	n = 16 493.94 (103.20)	0.400
AT-VE/VO2 *Mean (SD)*	n = 57 32.19 (5.15)	n = 30 33.63 (5.97)	n = 17 31.94 (4.35)	0.387
Operative fluid balance (liter) *Mean (SD)*	2.44 (1.23)	2.71 (1.25)	2.30 (1.29)	0.387
Preoperative Hemoglobin (g/l) *Median (IQR)*	130 (120-137)	132 (116-143)	135 (122-144)	0.339
Preoperative Albumin (g/l) *Median (IQR)*	40 (24-42)	39 (37-41)	40 (39-42)	0.277
Highest lactate (mmol/l) *Median (IQR)*	1.20 (0.9-1.7)	1.30 (1.15-1.95)	1.25 (1.10-1.70)	0.397

WHO PS: World Health Organisation Performance status; n: Number; l/min: Litres per minute; AT- VE/VCO2: Minute ventilation/carbon dioxide production at Anaerobic Threshold; SD: Standard Deviation; IQR: Interquartile Range; g/l: Grams per litre; mmol/l: Millimole per litre.

Table 7: Factors not significant with univariate analysis of peri-operative factors associated with having an elective or delayed tracheostomy.

	No vs. Elective		**No vs. Delayed**	
Variables	**RRR (95% CI)**	**p-value**	**RRR (95% CI)**	**p-value**
Age	1.02 (0.98-1.06)	0.989	0.98 (0.93-1.02)	0.303
Gender:				
Female	1	0.539	1	0.418
Male	1.45 (0.45-4.69)		1.90 (0.40-8.95)	
Nodes				
negative	1	0.239	1	0.359
positive	0.62 (0.28-1.38)		1.54 (0.61-3.84)	
WHO PS				
0	1		1	
1	1.18 (0.51-2.72)	0.701	1.17 (0.44-3.09)	0.751
2	4.33 (1.01-18.49)	0.048	2.5 (0.40-15.77)	0.330
3	1.73 (0.15-20.64)	0.664	2.5 (0.20-30.60)	0.472
Dietician input				
No	1	0.092	1	0.156
Yes	2.01 (0.89-4.53)		2.02 (0.76-5.35)	
Surgical technique:				
Lap-assisted	1	0.569	1	0.192
Open	1.25 (0.58-2.69)		1.88 (0.73-4.82)	

Neoadjuvant Chemo				
No	1	0.993	1	0.334
Yes	1.00 (0.36-2.82)		0.59 (0.20-1.73)	
Preoperative HB	1.00 (0.99-1.00)	0.673	1.00 (0.99-1.01)	0.785
Pre-op albumin	0.96 (0.88-1.06)	0.438	1.04 (0.92-1.18)	0.490
AT work	0.99 (0.97-1.01)	0.261	1.00 (0.98-1.02)	0.739
AT-VE/VO2	1.05 (0.97-1.15)	0.229	0.98 (0.89-1.09)	0.762
FEV1	0.81 (0.45-1.46)	0.481	0.45 (0.18-1.11)	0.083
FVC	0.76 (0.45-1.26)	0.288	0.49 (0.22-1.09)	0.081
Peak flow	1.00 (0.99-1.00)	0.263	1.00 (1.00-1.01)	0.595
Intraoperative fluid	1.00 (0.99-1.00)	0.067	1.00 (0.99-1.00)	0.839
Blood loss	1.00 (0.99-1.00)	0.242	1.00 (0.99-1.00)	0.532
Highest lactate	1.13 (0.64-2.00)	0.669	1.09 (0.54-2.19)	0.807

RRR: Relative Risk Ratio; WHO PS: World Health Organisation Performance status; pre-op: Pre-operative; HB: Hemoglobin; AT: Anaerobic threshold; AT- VE/VCO2: Minute ventilation/carbon dioxide production at Anaerobic Threshold; FEV1: Forced Expiratory Volume in one second; FVC: Forced Vital Capacity.

Table 8: Other outcome data.

Variables	**Tracheostomy**	**No n (%)**	**Yes n (%)**	**Odds Ratio (95% CI)**	**p-value**
Renal	No	97 (99)	1 (1)	1	0.525
	Delayed	22 (96)	1 (4)	4.41 (0.27-73.25)	
	Elective	35 (97)	1 (3)	2.77 (0.17-45.51)	
Cardiovascular	No	78 (80)	20 (20)	1	0.359
	Delayed	16 (70)	7 (30)	1.71 (0.62-4.71)	
	Elective	25 (69)	11 (31)	1.72 (0.72-4.07)	
Neurological	No	90 (92)	8 (8)	1	0.411
	Delayed	19 (83)	4 (17)	2.37 (0.65-8.68)	
	Elective	32 (89)	4 (11)	1.41 (0.40-4.99)	
Wound	No	94 (96)	4 (4)	1	0.164
	Delayed	20 (87)	3 (13)	3.53 (0.73-16.99)	
	Elective	35 (97)	1 (3)	0.67 (0.73-6.22)	
Infectious	No	84 (86)	14 (14)	1	0.391
	Delayed	17 (73)	6 (26)	2.12 (0.71-6.29)	
	Elective	30 (83)	6 (17)	1.20 (0.42-3.41)	

Table 9: Reason for tracheostomy insertion in delayed tracheostomy group.

Age	Sex	BMI	Day tracheostomy inserted	Reason for tracheostomy
49	MALE	36	2	SIRS, ventilation difficulties, likely prolonged respiratory wean
58	MALE	30	19	Pneumonia, multiorgan failure
71	MALE	23	10	Pneumonia, multiorgan failure
64	MALE	30	6	Pneumonia, Ankylosing spondylitis
64	MALE	20	8	Failed extubation, bilateral pneumothoracies, pneumonia, inappropriate neurologically, possible transient vocal cord palsy
66	MALE	32	3	Pneumonia, multiorgan failure
76	MALE	27	9	Surgical complication then ventilation difficulties
53	MALE	22	10	Pneumonia, thoracic duct leak
54	MALE	37	13	Ventilatory failure secondary pneumonia

40	MALE	34	1	Failed extubation, inadequate cough and inappropriate neurologically
65	MALE	30	6	Pneumonia, likely prolonged respiratory wean
51	FEMALE	32	1	Pneumonia, ventilation difficulties
55	MALE	28	2	Lung contusions, ventilation difficulties
57	MALE	28	2	Pneumonia, likely prolonged respiratory wean
71	MALE	29	3	SIRS, likely prolonged respiratory wean
66	MALE	25	1	Bleeding surface pleura with return theatre, likely prolonged respiratory wean
63	MALE	39	4	Pneumonia, multiorgan failure, likely prolonged respiratory wean
72	FEMALE	32	3	Pneumonia, high secretion load, difficulty ventilation
56	MALE	26	5	Pneumonia, high secretion load, likely prolonged respiratory wean
73	MALE	31	2	Pneumonia, likely prolonged respiratory wean
62	MALE	33	6	Biliary leak, ST elevation, likely long respiratory wean
45	MALE	40	2	SIRS likely prolonged respiratory wean
56	MALE	29	7	Pneumonia, poor cough, unable to clear secretions on extubation, required reintubation

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