Surgical Endoscopy (2019) 33:2345–2348
https://doi.org/10.1007/s00464-018-6536-y

2018 SAGES ORAL

Pre-operative characteristics and their role in prolonged intubation following abdominal wall reconstruction

Salvatore Docimo Jr.[1] · Konstantinos Spaniolas[1] · Maria Altieri[1] · Andrew Bates[1] · Mark Talamini[1] · Aurora Pryor[1]

Received: 12 May 2018 / Accepted: 12 October 2018 / Published online: 17 October 2018

Abstract

Background Patients undergoing abdominal wall reconstruction (AWR) are at an increased risk of developing respiratory complications. Previous studies have demonstrated that postoperative findings, such as an increase in plateau pressure greater than 6 cm H_2O following fascial closure, creates an increased risk of postoperative respiratory complications. The purpose of this study is to determine if specific preoperative characteristics are an indicator for postoperative respiratory failure.

Methods The 2005–2013 ACS-NSQIP participant use data were reviewed to evaluate post-operative intubation status following AWR procedures for ventral hernias. Prolonged intubation, defined as intubation up to 48 h post-operatively, was evaluated. Multivariable logistic regression was used to control for patient demographics and comorbidities. Odds ratios and 95% confidence intervals were reported as appropriate using SPSS.

Results 4378 patients were identified. Majority (51%) of patients were female. 2.96% of patients experienced a prolonged intubation. Factors such as a history of severe COPD, ASA 3 or 4, current smoker within 1 year, and a BMI of 40 were all found to have a significant association with a prolonged intubation.

Conclusions Post-operative prolonged intubation is a known complication of AWR. We have demonstrated that pre-operative factors, such as a history of COPD, ASA 3 or 4, current smoker, and a BMI > 40 kg/m^2 are factors associated with a prolonged intubation. Optimization of each may allow for a reduction in the risk of prolonged intubation in patients undergoing AWR.

Keywords Prolonged intubation · Component separation · Abdominal wall reconstruction · Post-operative complications · Respiratory failure

Significant advancements in the field of abdominal wall reconstruction (AWR), such as myofascial advancement flaps and retrorectus repair, have allowed a surgeon to perform complex closures on otherwise inoperable hernias. Despite the benefits AWR offers, repair of massive ventral hernias has also been associated with intra-abdominal hypertension (IAH) and respiratory dysfunction [1–3]. It has been estimated that component separation techniques can carry a pulmonary morbidity of 20% [4].

Measurements of intra-abdominal pressure (IAP), via a balloon-tipped nasogastric tube and a urinary catheter, have demonstrated an increase in IAP following ventral hernia repair, accompanied by deterioration of CO_2 elimination followed by a decrease in arterial oxygenation [5]. IAH is associated with a decrease in chest wall compliance and functional residual capacity, causing atelectasis and altering blood oxygen: carbon dioxide exchange [2, 6–8].

Previous data have associated postoperative respiratory complications with prolonged hospital stay, prolonged mechanical ventilation [4, 9], and nursing care requirements upon discharge [9], each leading to increased hospital charges [4]. Ventral hernia patients discharged with a diagnosis of respiratory failure and mechanical ventilation had a fourfold greater length of stay and 18-fold greater death rate [4]. Despite this, the ability to identify patients who are at high-risk for pulmonary complications preoperatively is unclear. The purpose of this study is to determine if specific preoperative characteristics are indicators for postoperative respiratory failure.

✉ Salvatore Docimo Jr.
Salvatore.docimo@stonybrookmedicine.edu

[1] Department of Surgery, Stony Brook University, 101 Nicolls Rd, HSC-19 T-053, Stony Brook, NY 11797, USA

Methods

Following Institutional Review Board (IRB) approval, patients undergoing AWR for ventral hernia were identified in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) between 2005 and 2013. ACS NSQIP is a prospectively collected data of pre-operative, intra-operative, and 30-day post-operative events collected through the use of a sampling algorithm. Patients were identified using the 9th International Classification of Disease diagnosis of a ventral or incisional hernia (553.2, 553.20, 553.21 or 553.29) and Current Procedural Terminology code used for component separation (15734). Patients' age < 18, missing data, ventilated pre-operatively, and non-elective procedures were excluded from analysis.

The primary endpoint was respiratory failure. This was evaluated separately as ventilator dependency for more than 48 h (prolonged intubation) or unplanned reintubation within 30 days. Explanatory variables included patient demographics, BM, race, American Society of Anesthesiologists (ASA) classification, co-morbidities, and intra-operative time. Multivariable logistic regression was used to control for patient demographics and comorbidities. Odds ratios (OR) and 95% confidence intervals (CI) were reported as appropriate. Statistical analysis was performed using SPSS version 25 for Windows (IBM, Somers, NY) and a significance level of 0.05.

Results

After application of the inclusion and exclusion criteria, 4488 patients undergoing AWR were identified. Majority (51%) were female, with BMI between 30 and 35 kg/m^2 ($n = 1212$, 27.0%) and 25–30 kg/m^2 ($n = 1167$, 26.0%). Approximately 2.96% ($n = 133$) of patients experienced prolonged intubation, while 108 (2.4%) patients experienced unplanned reintubation. There was no difference between BMI groups when examining unplanned reintubation ($p = 0.9$). Prolonged intubation was reported more commonly for patients with BMI > 40 kg/m^2, compared to < 35 kg/m^2 ($p < 0.001$). When examining factors associated with prolonged intubation, ASA 3 or 4 and having diabetes was significantly associated with prolonged intubation ($p < 0.0001$ and $p = 0.02$). In contrast, patients with a surgical procedure wound-classified as clean were less likely to have prolonged intubation (77.7% vs. 49.6%, $p < 0.0001$). In addition, having CVA/stroke with neurological deficits, dyspnea prior to surgery, COPD, HTN, smoker status, and functional status were associated with prolonged intubation ($p < 0.05$) (Table 1). Following multivariable logistic regression, factors such as a history of severe COPD, ASA 3 or 4, current smoker within 1 year, clean wound, and a BMI > 40 were all found to have a significant independent association with prolonged intubation (Table 2).

Discussion

Respiratory complications following complex AWR pose a significant clinical and financial burden with previous studies estimating 20% of patients suffering postoperative respiratory complications after AWR [4]. Our aim was to determine which risk factors demonstrated an increased risk of prolonged intubation. Most significant was the demonstration of an increased risk of prolonged intubation in those patients with a history of severe COPD, ASA 3 or 4, history of smoking within 1 year, and BMI > 40 kg/m^2.

Currently, no obvious algorithm exists to determine postoperative respiratory management of AWR patients. Blatnik et al. [4] evaluated 60 patients and noted an elevation in plateau pressure greater than or equal to 6 cm H_2O was almost nine times more likely to develop a respiratory complication. Plateau pressure is the pressure required to maintain an open air space once a breath is taken. An increase in plateau pressure may be due to a decrease in compliance of the chest wall due to abdominal distention brought on by the AWR procedure [4]. Blatnik et al. [4] demonstrated that the risk of developing a respiratory complication was increased as the change in plateau airway pressure increased, with an OR of 8.67 for a change in plateau pressure ≥ 6 cm H_2O and an OR of 11.5 for a change in plateau pressure ≥ 9 cm H_2O [4]. These findings were noted in patients with an average defect size over 400 cm^2 undergoing all attempts at fascial approximation. Blatnik et al. [4] suggested for those with an elevation in plateau pressure at 6 cm H_2O or higher to remain intubated for an additional 24 h to allow for a decrease in pressure.

AWR during ventral hernia repair has been associated with perioperative IAH as well. Development of IAH has been associated with respiratory dysfunction as it decreases chest wall compliance and functional residual capacity [5]. Gaidukov et al. [5] demonstrated an increase in IAP during surgical repair of ventral hernias is accompanied by deterioration in CO_2 elimination and a decrease in arterial oxygenation.

Previous attempts at identifying risk factors for pulmonary complications following abdominal surgery have been performed. Fischer et al. evaluated 1706 patients in an attempt to develop a validated predictive model and clinical risk-assessment tool of postoperative respiratory failure. The risk assessment tool stratified patients into low-,

Table 1 Univariate analysis identifying variables associated with prolonged intubation

Variable	No intubation	Prolonged intubation	*p* Value
White race	3544 (85.6%)	103 (83.7%)	0.602
Male gender	2095 (48.2%)	58 (43.6%)	0.3
ASA 3 or 4	2314 (53.2%)	102 (76.7%)	**< 0.0001**
Diabetes	808 (18.6%)	39 (29.3%)	**0.003**
Renal failure	40 (0.9%)	0	0.6
Clean wound	3382 (77.7%)	66 (49.6%)	**< 0.0001**
Male gender	2095	58	0.3
BMI groups			**0.01**
< 25	548 (12.9%)	12 (9.1%)	
25–30	1139 (26.8%)	28 (21.2%)	
30–35	1186 (27.9%)	26 (19.7%)	
35–40	736 (17.3%)	29 (22%)	
> 40	643 (15.1%)	37 (28%)	
> 10% weight loss in past 6 months	30 (0.7%)	0	0.4
CVA/stroke with deficits	2 (0%)	2 (1.5%)	**< 0.0001**
Pneumonia	2 (0.1)	0	0.8
Ascites	13 (0.3%)	1 (0.8%)	0.4
Dyspnea	453 (10.4%)	31 (23.3%)	**< 0.0001**
Alcohol dependence	43 (2.2%)	1 (1.4%)	0.7
Functional status			**< 0.0001**
Independent	4292 (98.6%)	125 (94%)	
Partially dependent	55 (1.3%)	7 (5.3%)	
Totally dependent	4 (0.1%)	0	
Unknown	4 (0.1%)	1 (0.8%)	
Hemiplegia	11 (0.6%)	0	0.5
Angina	8 (0.4%)	0	0.6
CHF	6 (0.1%)	0	0.7
COPD	242 (5.6%)	23 (17.3%)	**< 0.0001**
MI	3 (0.2%)	0	0.7
PVD	34 (1.8%)	3(4.3%)	0.1
TIA	40 (2.1%)	2 (2.9%)	0.7
Hypertension	2243 (51.5%)	85 (63.0%)	**0.005**
Steroid use	154 (3.5%)	6 (4.5%)	0.6
Smoker status	937 (21.5%)	48 (36.1%)	**< 0.0001**

Bold = significant

intermediate-, and high-risk categories based upon minor and major predictors. The model included both hernia repairs with and without mesh and concomitant component separation. Postoperative respiratory failure was defined as either an unanticipated intubation during the postoperative period or failure to wean form mechanical ventilation within 48 h. However, applications for the use of a predictor is difficult considering variables such as the size of the defect, type of mesh, fascial approximation (each of which could potentially impact IAPs and respiratory function) were not known and the definition of a postoperative respiratory complication is highly variable.

This study demonstrates factors such as a history of severe COPD, ASA 3 or 4, current smoker within 1 year, and a BMI > 40 kg/m^2 were noted to be statistically significant with a prolonged intubation. Of clinical importance is the fact current smoker within 1 year and a BMI > 40 kg/m^2 are both modifiable risk factors. A surgeon seeking to decrease the risk of prolonged intubation following AWR can opt to evaluate their operative candidate for the use of tobacco with nicotine testing or opt for surgical or medical weight loss interventions in patient with a BMI > 40 mg/m^2. Furthermore, COPD itself is not a modifiable risk factor; however, medical optimization prior to surgery can be attempted.

The need to limit prolonged intubation has both clinical and financial ramifications. Patients experiencing postoperative respiratory failure following open abdominal wall surgical repairs has been associated with longer hospital

Table 2 Logistic regression of factors significant for prolonged intubation

Variable	Odds ratio	95% CI		Significance *p* Value
		Lower	Upper	
Age > 90	1.007	0.99	1.024	0.43
History of severe COPD	1.79	1.05	3.06	**0.034**
ASA 3 or 4	1.76	1.11	2.77	**0.014**
Diabetes	1.2	0.796	1.82	0.379
Clean wound	0.344	0.240	0.493	**0.001**
Dyspnea	1.46	0.918	2.334	0.110
HTN	1.156	0.773	1.728	0.480
Current smoker within 1 year	1.96	1.31	2.93	**0.001**
BMI > 40	2.21	1.09	4.48	**0.029**

Bold = significant

admission (21 ± 18.5 vs. 5.9 ± 5.5 days, $p < 0.001$), a higher mortality rate (14.7% vs. 0.1%, $p < 0.001$) and an added cost of $60,933 per patient [9, 10].

Limitations do exist. The nature of the NSQIP dataset does not permit for accurate determination of defect size, type of component separation technique utilized, or if mesh was placed. CPT code 49568 does indicate "implantation of mesh;" however, determining use of mesh during an AWR approach would be difficult. Additionally, this study utilized CPT codes delineating AWR patients who underwent component separation, which may include open and minimally invasive surgical approaches. Studies evaluating pulmonary complications between open and minimally invasive approaches for ventral hernia repair should be performed. Specifics of intraoperative airway and bladder pressures were not known. Finally, the data does not represent outcomes beyond 30 days post-operatively as the NSQIP dataset does not capture this information.

Conclusion

Surgeons performing complex AWR need to take into account patient's postoperative respiratory function. Variables such as a history of severe COPD, ASA > 3, current smoker within the 1 year, and a BMI > 40 kg/m^2 were found to be predictive of prolonged intubation. Understanding these variables implies an elevated risk for a prolonged intubation and allows the surgeon to adequately plan for their post-operative care procedures and also preoperative optimization.

Compliance with ethical standards

Disclosures Dr. Salvatore Docimo reports personal fees from Boston Scientific, from null, during the conduct of the study; Dr. Aurora Pryor reports personal fees from Ethicon, personal fees from Medtronic, personal fees from Stryker, from Gore, grants from Baranova, grants from Obalon, outside the submitted work. Dr. Konstantinos Spaniolas, Dr. Maria Altieri, Dr. Andrew Bates, and Dr. Mark Talamini have no conflicts of interest or financial ties to disclose.

References

1. Blaser AR, Parm P, Kitus R, Starkopf J (2011) Risk factors for intra-abdominal hypertension in mechanically ventilated patients. Acta Anaesthesiol Scand 55:607–614
2. Pelosi P, Quintel M, Malbrain ML (2007) Effect of intra-abdominal pressure on respiratory mechanics. Acta Clin Belg Suppl 62(1):78–88
3. De Santis L, Frigo F, Bruttocao A, Terranova O (2003) Pathophysiology of giant incisional hernias with loss of abdominal wall substance. Acta Biomed 74(Suppl 2):34–37
4. Blatnik J, Krpata D, Pesa N et al (2012) Predicting severe postoperative respiratory complications following abdominal wall reconstruction. Plast Reconstr Surg 130:836–841
5. Gaidukov KM, Raibuzhis EN, Hussain A, Teterin AY, Smetkin AA, Kuzkov VV, Malbrain ML, Kirov MY (2013) Effect of intra-abdominal pressure on respiratory function in patients undergoing ventral hernia. World J Crit Care Med 2(2):9–16
6. Strang CM, Hachenberg T, Fredén F, Hedenstierna G (2009) Development of atelectasis and arterial to end-tidal PCO_2-difference in a porcine model of pneumoperitoneum. Br J Anaesth 103:298–303
7. DuBay DA, Choi W, Urbanchek MG et al (2007) Incisional herniation induces decreased abdominal wall compliance via oblique muscle atrophy and fibrosis. Ann Surg 245:140–146
8. Agnew SP, Small W, Wang E, Smith LJ, Hadad I, Dumanian GA (2010) Prospective measurements of intra-abdominal volume and pulmonary function after repair of massive ventral hernias with components separation technique. Ann Surg 251:981–988
9. Fishcer JP, Shang EK, Butler CE, Nelson JA, Braslow BM, Serletti JM, Kovach SJ (2013) Validated model for prediciting postoperative respiratory failure: analysis of 1706 abdominal wall reconstructions. Plast Reconstr Surg 132:826e–835e
10. Fischer JP et al (2014) Analysis of risk factors, morbidity, and cost associated with respiratory complications following abdominal wall reconstruction. Plast Reconstr Surg 133(1):147–156