Journal of Critical Care (2012) **27**, 417.e9–417.e13

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Journal of Critical Care

The frequency and significance of postintubation hypotension during emergency airway management[☆]

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Keywords:
Hypotension;
Intubation;
Mortality

Abstract

Objective: Arterial hypotension is a recognized complication of emergency intubation, but the consequence of this event is poorly described. Our aim was to identify the incidence of postintubation hypotension (PIH) after emergency intubation and to determine its association with inhospital mortality.

Methods: Retrospective cohort study of tracheal intubations performed in a large, urban emergency department over a 1-year period. Patients were included if they were older than 17 years and had no systolic blood pressure measurements less than 90 mm Hg for 30 consecutive minutes before intubation. Patients were analyzed in 2 groups, those with PIH, defined as any recorded systolic blood pressure less than 90 mm Hg within 60 minutes of intubation, and those with no PIH. The primary outcome was inhospital mortality.

Results: Of 465 patients who underwent emergency intubation, 336 met inclusion criteria and were analyzed. Postintubation hypotension occurred in 79 (23%) of 336 patients. Patients with PIH had significantly higher inhospital mortality (33% vs 21%; 95% confidence interval for 12% difference, 1%-23%) and longer mean intensive care length of stay (LOS) (9.7 vs 5.9 days, $P < .01$) and hospital LOS (17.0 vs 11.4 days, $P < .01$). Postintubation hypotension remained a significant predictor of inhospital mortality after adjusting for confounding using multivariable logistic regression analysis (odds ratio, 1.9; 95% confidence interval, 1.1-3.5).

Conclusion: Postintubation hypotension occurs in almost one quarter of normotensive patients undergoing emergency intubation. Postintubation hypotension is independently associated with higher inhospital mortality and longer intensive care unit and hospital LOS.

1. Introduction

Emergency airway management is fundamental to the care of critically ill patients. The use of a rapid acting hypnotic and neuromuscular blocking agent, collectively referred to as rapid sequence intubation (RSI), is widely considered the standard technique to facilitate emergency endotracheal intubation. Technical difficulties including

☆ None of the authors have a conflict of interest to report.

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doi:10.1016/j.jcrc.2011.08.011

procedural failure, esophageal intubation, pulmonary aspiration, and hypoxemia are the most commonly recognized immediate complications of RSI.

Arterial hypotension is generally considered a late sign of cardiovascular insufficiency that occurs once compensatory mechanisms to maintain blood pressure are overwhelmed or exhausted [1]. Transient and persistent hypotension are associated with mortality and organ dysfunction during acute illness [2,3]. Accordingly, preintubation hypotension has been associated with severe complications and death after emergency airway control [4,5].

Presently, there are conflicting data on the frequency of hemodynamic deterioration after emergency intubation, with some authors suggesting it is a rare complication [6-8] and others reporting it is relatively common [5,9-11]. However, no study has reported the direction and magnitude of effect of postintubation hypotension (PIH) on mortality. Although arterial hypotension typically triggers aggressive resuscitative efforts, hypotension has been described as a physiologic response to intubation due to multiple mechanisms including induction-associated sympatholysis and the effects of positive-pressure ventilation [12,13]. In the absence of data to determine effect, clinicians may assume that PIH is a benign, transient, or self-limited consequence of airway management [14]. We aimed to quantify the hemodynamic consequences of emergency intubation by studying the incidence and risk associated with PIH. Our hypothesis was that PIH after emergency intubation is associated with significantly higher inhospital mortality as compared with hemodynamic stability after intubation.

2. Methods

2.1. Study design and setting

We conducted a retrospective cohort study of consecutive patients requiring emergency airway management from January 1, 2007, to December 31, 2007, in the emergency department (ED) at Carolinas Medical Center, a large, urban teaching hospital with more than 100 000 patient visits per year. This ED is staffed by emergency medicine residents supervised by board-certified emergency physicians. All attending physicians are privileged for emergency airway management. Dedicated training in emergency airway management is included in the department yearly core curriculum and follows the guidelines of the The Difficult Airway Course. The Institutional Review Board and Privacy Board of Carolinas Healthcare System approved this study under waiver of informed consent.

2.2. Selection of patients and data collection

A mandatory audit tool for quality assurance is completed for all ED intubations at our facility. All adult patients (>17 years old) undergoing emergency endotracheal intubation and who had no systolic blood pressure (SBP) measurements less than 90 mm Hg for 30 consecutive minutes before intubation were eligible for this study. Patients were excluded if they were intubated before arrival, required vasopressor support, or had cardiac arrest within 30 minutes of intubation. We used a 2-step pathway to identify eligible study subjects. First, we queried the prospectively collected ED intubation quality assurance database for all patients meeting inclusion criteria during the study period. To ensure that no patients were missed, we then cross referenced all potential subjects with our ED billing database for the procedure code of endotracheal intubation.

A standardized data collection instrument and guidance tool was developed for data collection. Record review and data abstraction were performed by a single research assistant who underwent a standard training program for data abstraction. Regular meetings were conducted to address any problems encountered during the data collection phase. A random sample of 10% of charts was abstracted by a second reviewer who was blinded to the findings of the first observer to assess interobserver reliability as we have previously described [15]. Collected data elements included demographic information, medical history, outpatient and ED medications, ED clinical variables, and primary indication for emergency airway management.

For purposes of data analysis, patients were divided into 1 of 2 groups according to the presence or absence of PIH. *Postintubation hypotension* was defined as any recorded SBP less than 90 mm Hg within the 60-minute postintubation period. The primary outcome measure was inhospital mortality. Among survivors, we defined secondary outcomes of hospital and intensive care unit (ICU) length of stay (LOS).

2.3. Data analysis

Continuous data are presented as means ± SD or medians and interquartile ranges and, when appropriate, were compared for statistical differences using unpaired *t* tests or Mann-Whitney *U* tests. Interobserver variability was examined with Cohen κ. Categorical data are reported as proportions and associated 95% confidence intervals (CIs) and, where applicable, tested for significance using χ^2 test or Fisher exact test. For all statistical tests, $P < .05$ was considered significant.

To account for potential confounders, a multivariate logistic regression model was created using inhospital death as the dependent variable. Odds ratios (ORs) were calculated to determine independent predictors of inhospital mortality using multivariable logistic regression with bootstrap correction for 95% CIs. Candidate variables were selected based on known predictors of mortality and differences in survivors and nonsurvivors in the bivariate analysis, and the model was refined using reverse stepwise elimination. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test. In the model, bias-corrected ORs were calculated using the bootstrap methods with 1000 iterations. All statistical analyses were done with a commercially available software package (StatsDirect v 2.3.2, StatsDirect LTD; Cheshire, United Kingdom).

3. Results

We identified 542 patients who underwent ED endotracheal intubation during 2007, and 336 patients were analyzed in this study (Fig. 1). The demographic and clinical characteristics of the study subjects are shown in Table 1. Two independent reviewers had excellent agreement for the determination of the variable of PIH present or absent (κ = 0.85; 95% CI, 0.61-1.0). Most patients received etomidate and succinylcholine for RSI. Postintubation hypotension was observed in 79 (23%; 95% CI, 19-28) of 336 patients. The median time to first PIH was 11 minutes (interquartile range, 2-27 minutes). Of 336 patients (5%; 95% CI, 3-7), 15 received catecholamine support to reverse PIH. Patients with PIH were slightly older, had more comorbid disease burden, and were more likely to be on chronic β-blocker therapy. These patients also had lower mean SBP immediately before intubation and were more likely to require intubation for acute respiratory failure and to receive neuromuscular blockade as part of the RSI regimen.

Of the 336 patients, 79 died in the hospital for an overall mortality rate of 24% (95% CI, 20%-29%). Table 2 shows the primary and secondary outcomes of the study. Patients in the PIH group had significantly higher inhospital mortality (33% vs 21%; 95% CI for difference of 12%, 1-24), and PIH was associated with a 90% increase in odds of inhospital death (OR, 1.9; 95% CI, 1.1-3.2) compared with patients without PIH. Among survivors, PIH was associated with significantly increased mean ICU and hospital LOS.

Seven demographic and predictor variables associated inhospital mortality, including PIH, age, race, sex, left ventricular dysfunction, hypertension, and chronic obstructive pulmonary disease, were entered into the regression analysis (Table 3). Multivariate logistic regression analysis confirmed PIH as an independent predictor of inhospital mortality (OR, 1.9; 95% CI, 1.1-3.5) with this model demonstrating good fit using the Hosmer-Lemeshow goodness-of-fit test (P = .50).

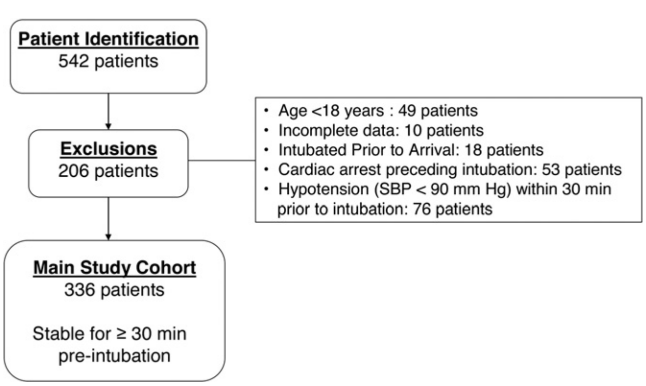

Fig. 1 Patient identification and exclusions for 542 patients intubated in 2007.

Table 1 Population characteristics grouped by outcome

Variable	Total group (n = 336)	PIH absent (n = 257)	PIH present (n = 79)	P
Age (y)	49 ± 19	47 ± 19	53 ± 20	.03
Sex (male)	217 (65)	168 (65)	49 (62)	.59
Race (white)	162 (48)	122 (47)	40 (51)	.39
Weight (kg)	82 ± 23	81 ± 22	83 ± 23	.59
Comorbidities				
Coronary artery disease	34 (10)	21 (8)	13 (16)	.05
Left heart failure	22 (7)	11 (4)	11 (14)	<.01
Atrial fibrillation	27 (8)	18 (7)	9 (11)	.24
Hypertension	146 (43)	108 (42)	38 (48)	.37
Pulmonary hypertension	13 (4)	8 (3)	5 (6)	.17
COPD	40 (12)	25 (10)	15 (19)	.05
Asthma	24 (7)	17 (7)	7 (9)	.46
End-stage liver disease	16 (5)	10 (4)	6 (8)	.22
End-stage renal disease	21 (6)	13 (5)	8 (10)	.11
Diabetes mellitus	79 (24)	52 (20)	27 (34)	.01
Outpatient medications				
ACE inhibitor	59 (18)	47 (18)	12 (15)	.61
β-Blocker	63 (19)	40 (16)	23 (29)	.01
Calcium-channel blocker	52 (16)	37 (14)	15 (19)	.37
Case category				
Medical	197 (59)	148 (58)	49 (62)	.52
Trauma	139 (41)	109 (42)	30 (38)	
Reason for intubation				
Airway protection	261 (78)	212 (83)	49 (62)	<.01
Respiratory insufficiency	66 (20)	40 (16)	26 (33)	
Other	9	5	4	
Clinical variables				
SBP immediately before RSI (mm Hg)	154 ± 40	159 ± 38	137 ± 42	<.01
Induction with etomidate	310 (92)	238 (93)	72 (91)	.64
Etomidate dose (mg/kg)	0.31 ± 0.1	0.32 ± 0.1	0.32 ± 0.1	.98
RSI paralysis used	328 (98)	254 (99)	74 (94)	.02
Paralysis with succinylcholine	282 (84)	215 (84)	67 (85)	.86

COPD indicates chronic obstructive pulmonary disease; ACE, angiotensin-converting enzyme.

4. Discussion

In this study, we document that PIH occurs in nearly one quarter of patients who are hemodynamically stable before intubation and that PIH is associated with inhospital mortality. Furthermore, among survivors, PIH is associated with significantly prolonged ICU and hospital LOS. When controlling for other variables, PIH is an independent

Table 2 Hospital mortality and ICU and hospital LOS

Variable	PIH absent (n = 257)	PIH present (n = 79)	Difference (95% CI)	P
Hospital mortality	54 (21)	26 (33)	12 (1-23)	.03
Hospital LOS, d	11.4 ±12.3	17.0 ± 14.2	5.5 (1.6-9.5)	<.01
ICU LOS, d	5.9 ± 7.2	9.7 ± 11.0	3.8 (1.3-6.3)	<.01

predictor of inhospital mortality. We believe this to be the first study to show this association.

Our study adds to the body of literature highlighting hypotension as an important marker of critical illness and adverse outcome [3]. Systemic hypotension defines uncompensated shock, which is generally considered a late sign of cardiovascular insufficiency that occurs once compensatory mechanisms to maintain normal perfusion pressure are either overwhelmed or exhausted. Previous studies suggest that both the degree and duration of hypotension are associated with adverse events in a dose-response manner and that even transient hypotension is associated with adverse events [2,3,16,17].

Specific to airway management, preintubation shock is associated with severe complications and death after emergency airway control [4,5]. Similarly, postinduction and unintentional intraoperative hypotension during general anesthesia are associated with increased mortality [18,19]. Our study extends these findings, suggesting that hypotension immediately after emergency intubation is associated with an increased risk of inhospital death.

The incidence of PIH in our study is consistent with complication rates described in focused reports of emergency intubation outside the ED [5,9,10,20]. However, our incidence of PIH is higher than several previous ED-based studies [6-8]. One explanation for these conflicting findings are variable definitions used for complications (ie, hypotension) [21]. Another explanation is the potential bias associated with self-reporting of complications used in these studies and the potential for either underreporting or underappreciation of the importance of PIH, including transient PIH, as an adverse event. One of the strengths of our study was that we used systematic definitions of PIH and hard documentation of data rather than self-reporting.

Table 3 Results of logistic regression analysis for the end point of inhospital mortality

Variable	OR	95% CI
COPD	0.3	0.1-1.0
DM	1.1	0.5-2.1
HTN	0.9	0.5-1.8
LHF	1.1	0.4-3.1
Male sex	1.4	0.8-2.4
Age >50 y	2.9	1.5-5.7
PIH	1.9	1.1-3.5

Model analysis.
Pearson χ^2 goodness of fit, $P = .1784$.
Deviance goodness of fit, $P = .1446$.
Hosmer-Lemeshow test, $P = .4992$.
Abbreviations: DM - diabetes mellitus; HTN - hypertension; LHF - left heart failure.

Our data establishes an association between PIH and inhospital mortality but cannot discriminate whether hypotension causes injury or is simply associated with worsened comorbidity. The data generate the hypothesis that among critically ill patients, frank hypotension induced by intubation may act as a secondary insult that incites or advances hypoperfusion and directly contributes to organ dysfunction. One potential next step is a controlled trial using vasopressor support after intubation to forestall hypotension and determine effect on mortality. Alternatively, PIH may represent a high-risk marker of cardiovascular insufficiency and adverse outcome that warrants an early and organized hemodynamic resuscitation approach [22-25].

There are several limitations to our report that warrant discussion. First, this was a retrospective analysis and, as such, is associated with potential biases. To address these potential biases, we followed the steps recommended to minimize validity threats in chart review studies [26]. Although yearly airway education at our center seeks to provide consistent best practice, airway management is not rigidly standardized. Second, this study was performed at a single urban tertiary care hospital, and these results may not be generalizable to other centers treating a different patient population including those with a dissimilar level of acuity. Third, our patients were monitored via noninvasive blood pressure assessment, and preintubation and postintubation hemodynamic changes may have gone undetected due to the intermittent nature of this monitoring. In addition, we only studied the presence of hypotension and did not attempt to document abnormal oxygen delivery, organ dysfunction, or other signs suggestive of shock.

In conclusion, PIH is a common complication of emergency intubation and is associated with an increased risk of inhospital mortality. Future studies should investigate therapeutic strategies that may improve outcomes of patients with PIH.

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