

National Costs of Complications Associated with Emergent Endotracheal Intubations

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Research Objective:

- To estimate the national cost burden to providers of complications associated with multiple endotracheal (ET) intubation attempts in the emergent (non-OR) setting

Introduction:

- Approximately 3 million ET intubations are performed outside of the OR in the U.S. every year
- Requiring multiple attempts for successful placement of an ET tube exponentially increases risk for peri-intubation complication events (esophageal intubation, hypotension, hypoxemia, macro aspiration, and cardiac arrest)
- The currently accepted first-pass success rate (FPS) for ET tube placement in the emergent (non-OR) setting is 84%

Study Design:

- An expected value approach using decision analysis software (TreeAge® Pro) was utilized where the hypothetical decision node was FPS of 100% or FPS of <100%
- Costs were estimated from a provider perspective and inflated to 2018 USD
- The stopping point in the model was the 3rd attempt at ET tube placement
- Sensitivity analyses were performed to investigate how avoidable costs changed with each model parameter

Parameter	Rate on 1 st Attempt	Rate on 2 nd Attempt	Rate on 3 rd Attempt	Cost per case (range)
Aspiration	0.3%	2.3%	13.0%	\$10-90K
Hypoxemia	4.8%	33.1%	70.0%	\$5-20K
Cardiac Arrest	0.1%	0.4%	11.0%	\$17-50K
Hypotension		24.0%		\$5-20K
Esophageal Intubation		4.0%		\$5-20K

Principal Findings:

FPS Rate	Weighted Cost Per Intubation	Estimated No. of Complications	Estimated Cost to Providers (per yr, 2018 USD)
100%	\$1,682	993,722	\$5.05 billion
84%	\$1,979	1,161,316	\$5.93 billion
Potentially Avoidable	n/a	167,594	\$890 million

Conclusions:

- The burden of complications and costs associated with intubation of the critically ill in the emergent, non-OR is large in magnitude
- Increasing the FPS rate from 84% to nearly 100% could yield large cost savings to providers

Implications for Policy:

- Methods known to increase FPS during emergent placement of ET tubes should be considered for incorporation into practice guidelines

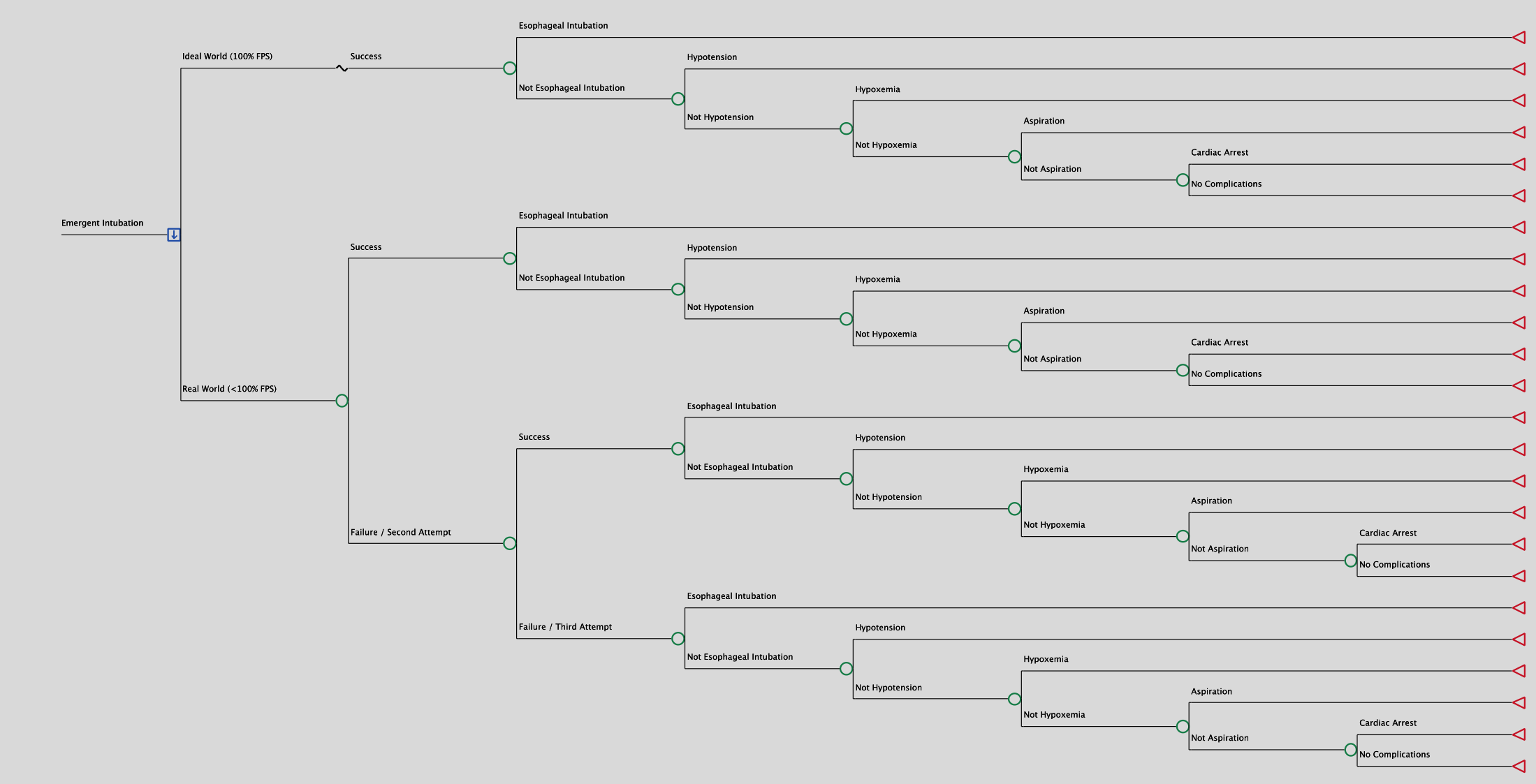
References

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Increasing first-pass success during emergent intubation from 84% to 100% could avoid 168,000 peri-intubation complications and \$890 million per year for U.S. providers.



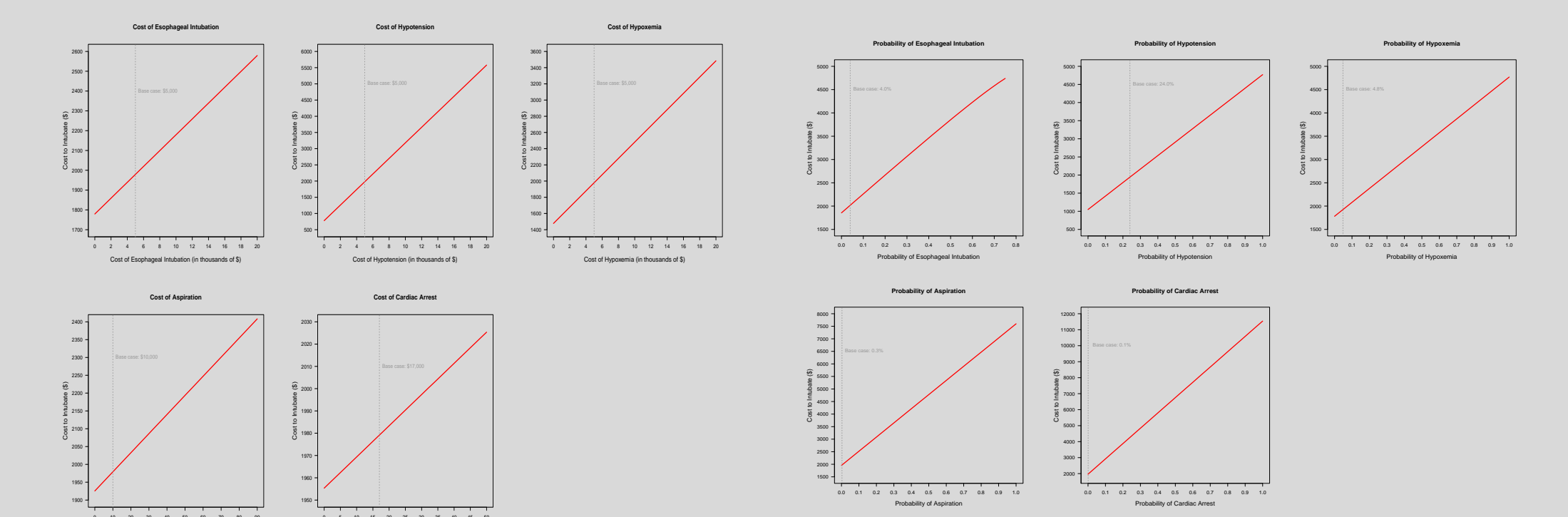
Parameter	Value Used in Base Case	Range Analyzed		Literature Reference
		Lower	Upper	
Probability of Success				
On 1st Attempt	0.841	0	1	Park et al. (2017)
On 2nd Attempt	0.852	0	1	Diggs et al. (2014)
Probability of Aspiration				
On 1st Attempt	0.003	0	1	Mort et al. (2004); Sakles et al. (2013)
On 2nd Attempt	0.023	0	1	Mort et al. (2004); Sakles et al. (2013)
On 3rd Attempt	0.130	-	-	Mort et al. (2004); Sakles et al. (2013)
Probability of Hypoxemia				
On 1st Attempt	0.048	0	1	Mort et al. (2004); Sakles et al. (2013)
On 2nd Attempt	0.331	0	1	Mort et al. (2004); Sakles et al. (2013)
On 3rd Attempt	0.700	-	-	Mort et al. (2004); Sakles et al. (2013)
Probability of Cardiac Arrest				
On 1st Attempt	0.001	0	1	Mort et al. (2004); Sakles et al. (2013)
On 2nd Attempt	0.004	0	1	Mort et al. (2004); Sakles et al. (2013)
On 3rd Attempt	0.110	-	-	Mort et al. (2004); Sakles et al. (2013)
Probability of Hypotension				
On 1st Attempt	0.24	0	1	Bernhardt (2019); Tabota (2019)
On 2nd Attempt	0.24	0	1	Bernhardt (2019); Tabota (2019)
On 3rd Attempt	0.24	-	-	Bernhardt (2019); Tabota (2019)
Probability of Esophageal Intubation				
On 1st Attempt	0.04	0	1	Casny (2018); Bernhardt (2019); Dejung (2019)
On 2nd Attempt	0.04	0	1	Casny (2018); Bernhardt (2019); Dejung (2019)
On 3rd Attempt	0.04	-	-	Casny (2018); Bernhardt (2019); Dejung (2019)
Costs (2017 USD)				
Aspiration Event	\$10,000	\$10,000	\$90,000	Boyer et al. (1991) Siddique et al. (2000) Warren et al. (2003) Kattan et al. (2007) Tong et al. (2018) Chausse et al. (2018)
Hypoxemia	\$5,000	\$5,000	\$20,000	(Expert Opinion)
Cardiac Arrest	\$17,000	\$17,000	\$50,000	Kolte et al. (2015) Dalmatava et al. (2016) Gier et al. (2017) Eid et al. (2017)
Hypotension	\$5,000	\$5,000	\$20,000	(Expert Opinion)
Esophageal Intubation	\$5,000	\$5,000	\$20,000	(Expert Opinion)

	Complications Type	Estimated No. of Cases	Costs (2018 USD)			National Cost Estimate		
			Cost Per Case	Range Analyzed	Point Estimate	Lower Estimate	Upper Estimate	
First Pass Success Rate = 100%	Esophageal Intubation	120,000	\$5,000	\$2,000 - \$10,000	\$600,000,000	\$240,000,000	\$1,200,000,000	
	Hypoxemia	720,000	\$5,000	\$2,000 - \$10,000	\$3,600,000,000	\$1,440,000,000	\$7,200,000,000	
	Hypoxemia Aspiration	142,105	\$5,000	\$2,000 - \$10,000	\$710,526,318	\$284,210,526	\$1,421,052,632	
	Aspiration	8,716	\$10,000	-	\$87,156,160	-	-	
	Cardiac Arrest	2,901	\$17,000	-	\$49,323,132	-	-	
	Total w/ Complications	993,722	-	-	\$5,047,005,588	-	-	
First Pass Success Rate = 84.1%	Esophageal Intubation	120,000	\$5,000	\$2,000 - \$10,000	\$600,000,000	\$240,000,000	\$1,200,000,000	
	Hypoxemia	720,000	\$5,000	\$2,000 - \$10,000	\$3,600,000,000	\$1,440,000,000	\$7,200,000,000	
	Hypoxemia	301,027	\$5,000	\$2,000 - \$10,000	\$1,505,136,138	\$602,054,455	\$3,010,272,276	
	Aspiration	16,087	\$10,000	-	\$160,874,665	-	-	
	Cardiac Arrest	4,201	\$17,000	-	\$71,423,018	-	-	
	Total w/ Complications	1,161,316	-	-	\$5,937,435,831	\$2,314,354,148	\$11,642,571,969	
Avoidable Cases and Costs	Esophageal Intubation	0	\$5,000	\$2,000 - \$10,000	\$0	\$0	\$0	
	Hypoxemia	0	\$5,000	\$2,000 - \$10,000	\$0	\$0	\$0	
	Hypoxemia Aspiration	158,822	\$5,000	\$2,000 - \$10,000	\$794,000,822	\$317,843,929	\$1,589,219,645	
	Aspiration	7,372	\$10,000	-	\$73,718,325	-	-	
	Cardiac Arrest	1,300	\$17,000	-	\$22,101,896	-	-	
	Total Avoidable Complications	167,594	-	-	\$890,430,243	\$413,644,350	\$1,685,040,066	

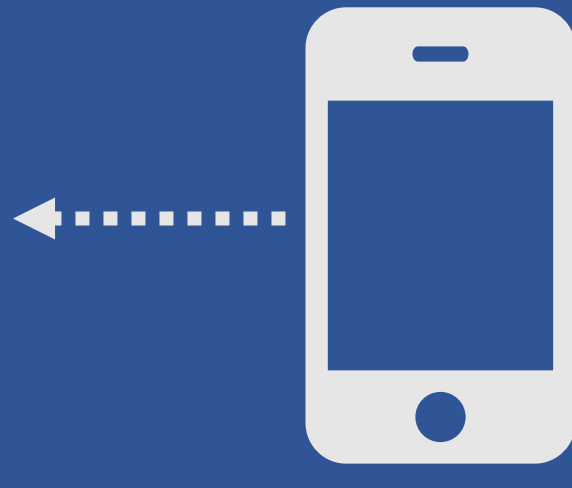
Assuming 3 million emergent intubations performed per year in the United States
 Avoidable Complications and Avoidable Costs calculated with 100% first pass success rate as the reference
 The model assumed rates of esophageal intubation and hypotension (4% and 24%, respectively) did not vary by number of attempts.

First-Pass Success Rate	Point Estimate	Weighted Cost Per Intubation Case	National Estimate*	Avoidable Costs
One-hundred percent	100%	\$1,682	\$5,047,200,000	REFERENCE
Park et al. (2017) Meta-Analysis Values				
ED**	84.1%	\$1,979	\$5,937,615,900	\$890,415,900
Trauma	81.8%	\$2,022	\$6,066,418,200	\$1,019,218,200
N. America	82.3%	\$2,013	\$6,038,417,700	\$991,217,700

*Assuming 3 million intubations performed annually
 **Base Case used in our model
 Note: Avoidable costs for base case shown in this table (\$890,415,900) will vary slightly from the estimate shown in Table 2 (\$890,430,243) due to rounding. This is true for the National Estimates shown in Table 2 versus Table 3, as well.



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