

*Quantitative Modeling of Intubation at
Scale
An Open-Source Intubation Calculator*

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Disclosures

Runnels

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Norris

None

Understanding Objectives

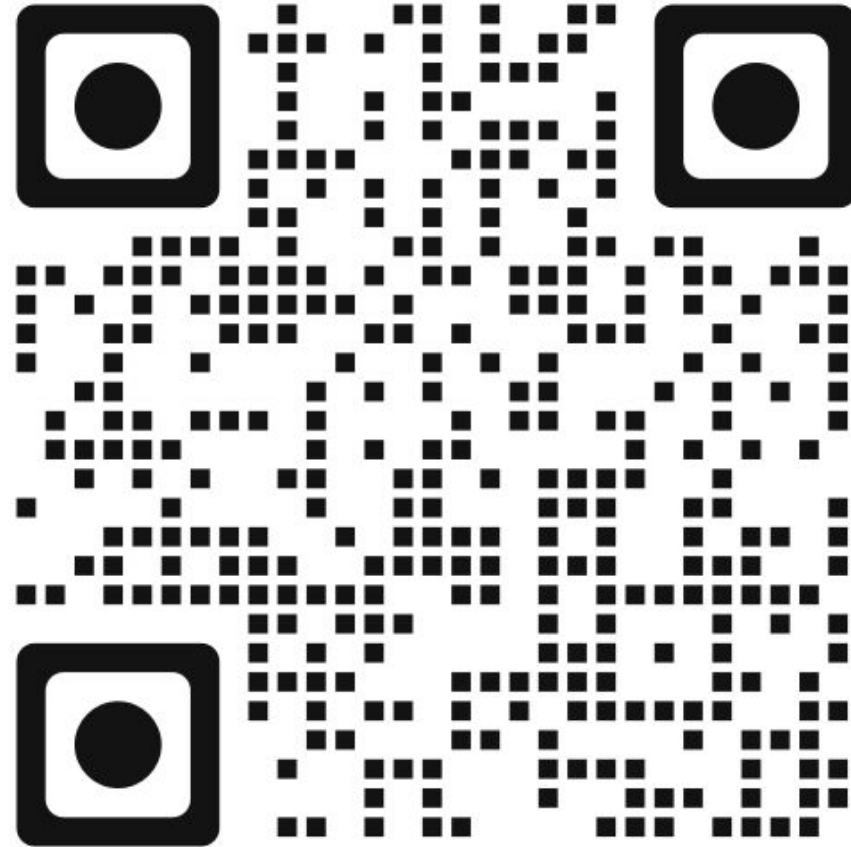
- Modeling DL era to VL era transition
 - Clinical outcomes
 - Economic outcomes
 - Cause and scaled impact of first pass failure

Why Build a Mathematical Model of Intubation Practices??

- Data Integration
- Scenario Building
- Prediction and insight
- Scaling Outcomes
- Decision Support



Link to Calculator



<https://sites.google.com/view/intubation-calculator/edicu-intubation-calculator>

Intubation Calculator

Thinking at Population Scale

To begin, select your intubation location below.

ED/ICU

Operating Room

WAMM 2025 Abstract

Questions for the Calculator



***What is the main cause of
first pass failure
as VL use increases?***



DL Clinical Problem!

“Can Not See”

Visualization Failure

VL Clinical Problem!

“I Can See The Cords, But I Can’t Deliver the Tube!”

Tracheal Access Failure

A prospective cohort evaluation of the McGrath™ MAC videolaryngoscope in a series of 979 cases

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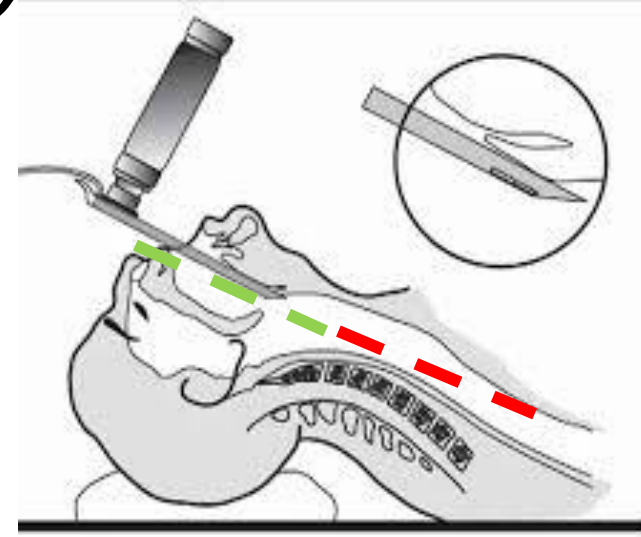
^d NHS Lothian, Western General Hospital, Crewe Road South, Edinburgh, EH4 2XU, UK

VL vs DL *Kriege 2023 (OR)*



First pass rate

- VL 94%
- DL 82%




Failure Mode

	DL	VL
Visualization	84%	14%
Tracheal access	16%	86%

First Pass Failure and Attempt Failure Mode

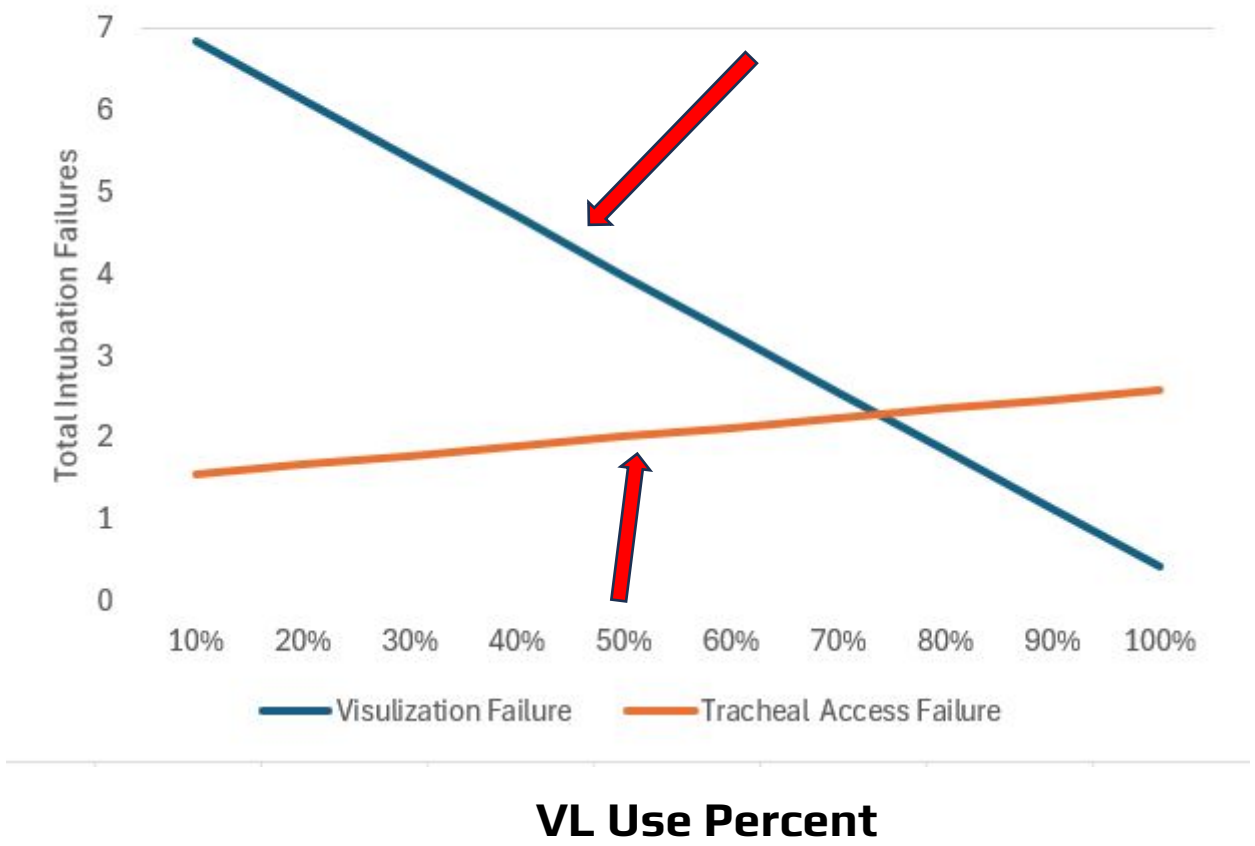
OR intubations (Kriege 2023)

Operating Room
Intubation Failures Calculator

INSTRUCTIONS		Enter the total number of intubations --->						
Total number of first pass intubation failures for a given VL and DL usage. To use number of intubations to be analyzed. Conceptually, this may be the total number of intubations globally, nationally, institutionally etc.		25,000,000 						
VL Use	DL Use	VL First Pass Failure Rate (Kriege et al.)	DL First Pass Failure Rate (Kriege et al.)	VL First Pass Failures	DL First Pass Failures	Total First Pass Failures	Visualization Failures	Trachea Access Failures
10%	90%	6%	18%	150,000	4,050,000	4,200,000	3,423,000	777,000
20%	80%	6%	18%	300,000	3,600,000	3,900,000	3,066,000	834,000
30%	70%	6%	18%	450,000	3,150,000	3,600,000	2,709,000	891,000
40%	60%	6%	18%	600,000	2,700,000	3,300,000	2,352,000	948,000
50%	50%	6%	18%	750,000	2,250,000	3,000,000	1,995,000	1,005,000
60%	40%	6%	18%	900,000	1,800,000	2,700,000	1,638,000	1,062,000
70%	30%	6%	18%	1,050,000	1,350,000	2,400,000	1,281,000	1,119,000
80%	20%	6%	18%	1,200,000	900,000	2,100,000	924,000	1,176,000
90%	10%	6%	18%	1,350,000	450,000	1,800,000	567,000	1,233,000
100%	0%	6%	18%	1,500,000	0	1,500,000	210,000	1,290,000

Cause-Specific Rates of OR First-Pass Intubation Failure (per 50M)

Chart Area



Insight

As VL use increases:

Total first pass failures decrease

First pass failure due to ***visualization*** decreases

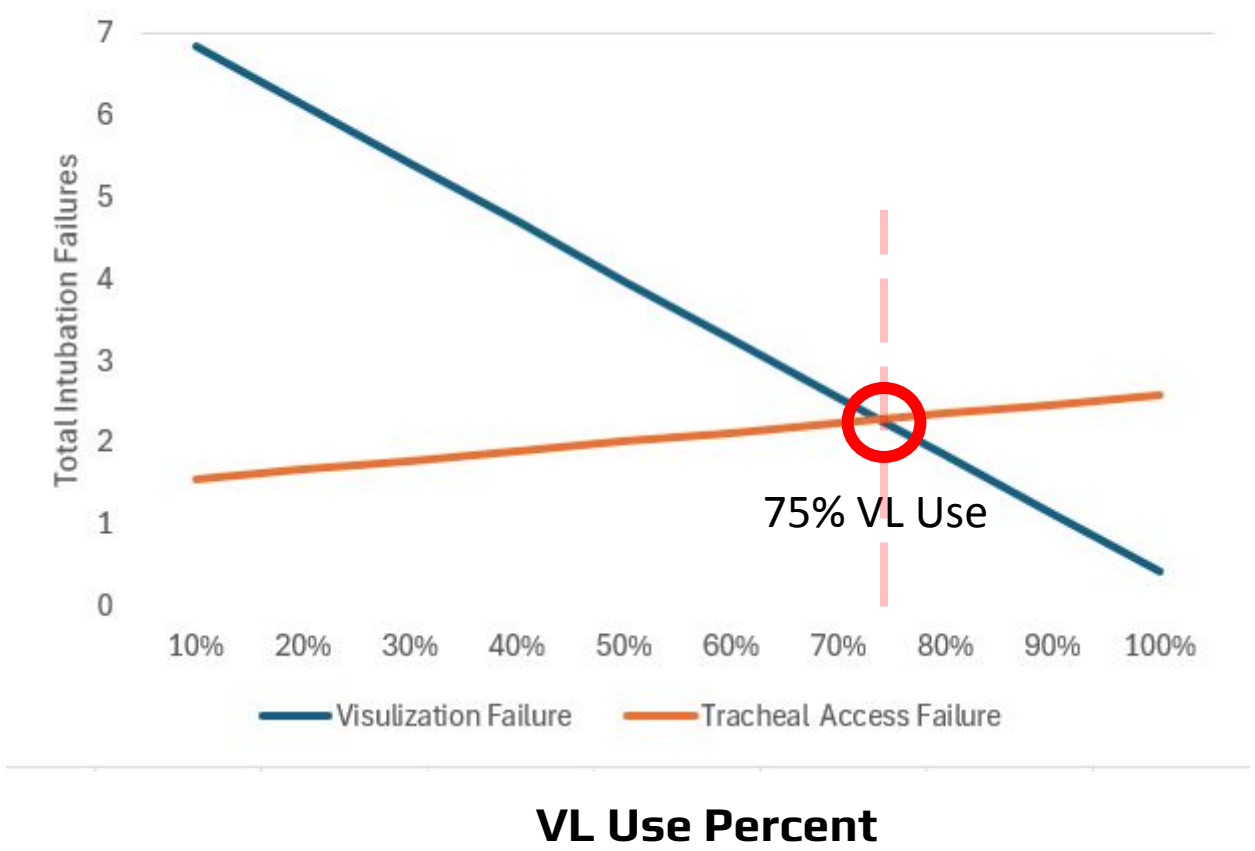
First pass failure due to ***tracheal access issues*** increases

***When Will Failure of Tracheal Access
Overtake Failure of Visualization As the
Main Cause of First Pass Failure??***



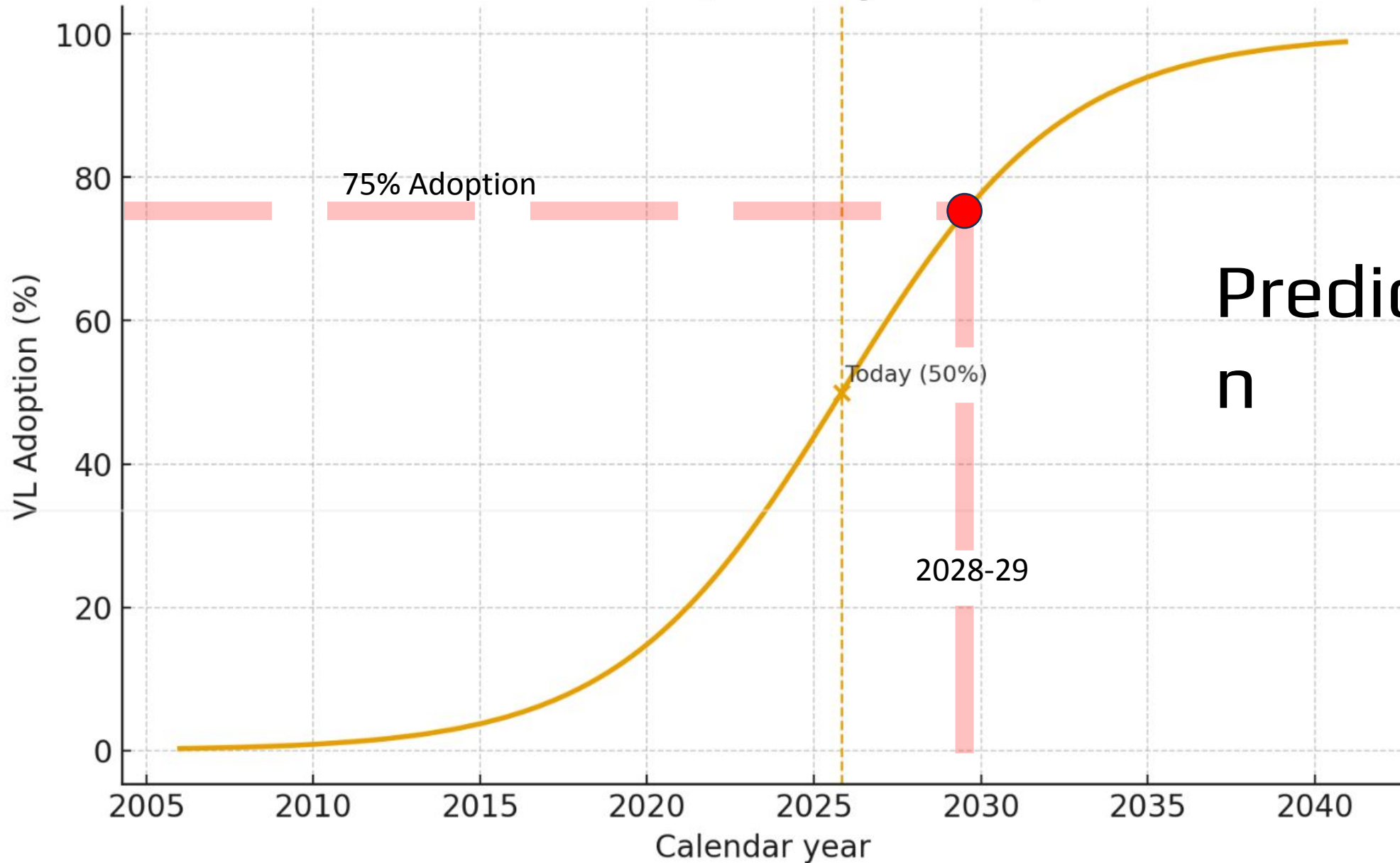
Cause-Specific Rates of OR First-Pass Intubation Failure (per 50M)

Chart Area



VL Market Adoption — Logistic (Sigmoid) Curve

Introduced 2006; 50% by Oct 31, 2025



What Is the Excess Cost of 3+ Intubation Attempts in OR per Year in the USA??



Economic Cost and
Scale

COST BURDEN ASSOCIATED WITH DIFFICULT INTUBATION IN THE UNITED STATES

Abstracts / Trends in Anaesthesia and Critical Care 30 (2020)

Karen Phillips ¹,
e1ee192

Inpatient Surgical Admissions	N ²	Median Cost
Admissions with difficult intubations	4,598	\$33,171
Admissions without difficult intubations	9,980,862	\$12,940
Cost difference		\$20,231



Operating Room — Intubation Failures Calculator

Outputs match **Table 1** exactly. Only G3 is editable.

G3 — Total number of intubations

editable

25000000

All results update instantly.

Scenario	Total First Pass Failures	Visualization Failures	Tracheal Access Failures	Intubations Requiring ≥ 3 Attempts
20% VL + 80% DL	3,900,000	3,066,000	834,000	390,000
100% VL + 0% DL	1,500,000	210,000	1,290,000	150,000
Difference	2,400,000	2,856,000	-456,000	240,000

Calculations: B-row = total FP failures; C-row = visualization-related failures; D-row = tracheal-access-related failures; E-row = 10% of FP failures.

20% VL

$\$20,000 \times 390,000 = \7.8 Billion

100% VL

$\$20,000 \times 150,000 = \3.9 Billion

Savings....\$3.9 Billion


***Should I do 30% of my intubations with
DL to keep up my DL skills??***



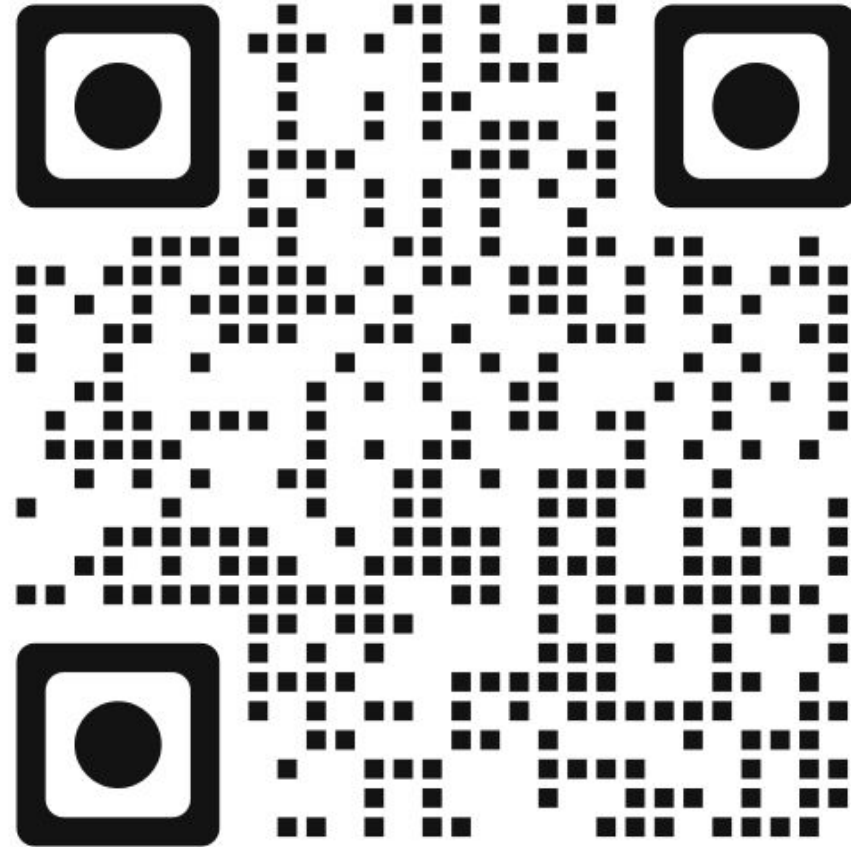
Decision
Support

The Cost of Retaining DL Skills

- 30% of intubations with DL

	ED/ICU (10M)	OR (50M)
First Pass Failures @ 30% DL	1,919,000	4,800,000
First Pass Failures@ 100% VL	1,490,000	3,000,000
Excess First Pass Failures	429,000	1,800,000
Excess Deaths and costs		

Link to Calculator



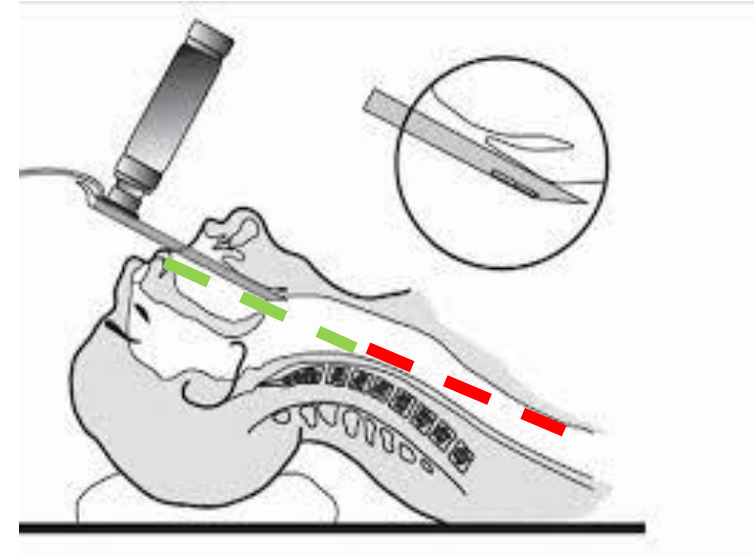
<https://sites.google.com/view/intubation-calculator/edicu-intubation-calculator>

***What Is the cost in 28-day ICU mortality at
20% VL use and 100% VL use?***



**Clinical Cost and
Scale**

VL vs DL *Prekker 2023 (ED ICU)*



First pass rate

- VL 85.1%
- DL 70.8%

Failure Mode

	DL	VL
Visualization	71%	34%
Tracheal access	29%	66%

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Intubation Practices and Adverse Peri-intubation Events in Critically Ill Patients From 29 Countries

Vincenzo Russotto, MD; Sheila Nainan Myatra, MD; John G. Laffey, MD, MA; Elena Tassistro, MS;

Linked

of intubation attempts

major adverse events

28 Day ICU mortality

National Scale Critically Ill (5 Million Per Year)

ED/ICU Critically Ill Intubations

Only G3 (Total number of intubations) is editable. Results update instantly.

G3 — Total number of intubations

editable

5000000

Scenario	Total First Pass Failures	Major Adverse Events	28-Day Deaths	Visualization Failures	Tracheal Access Failures
20% VL + 80% DL	1,310,000	694,300	90,953	874,600	435,400
100% VL + 0% DL	750,000	397,500	52,073	255,000	495,000
Difference	560,000	296,800	38,881	619,600	-59,600

Definitions: FP Failures = total × (VL%×VL_FP + DL%×DL_FP). MAE = FP Failures × 0.53. 28-day deaths = MAE × 0.131. Visualization/Tracheal Access split uses VL/DL-specific proportions.