Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Implementation of a Multidisciplinary, Pre-intubation Airway Checklist at a Level 1 Trauma Center

Tianyu Tang

tianyu.tang@ucsf.edu

University of California, San Francisco

Newton Addo

University of California, San Francisco

Elizabeth Liu

Highland Hospital

Justin Teng

Kaiser Permanente South Sacramento Medical Center

Matthew Roces

University of California, Los Angeles

Joseph Brown

University of Colorado Hospital

Kayla Enriquez

University of California, San Francisco

Research Article

Keywords:

Posted Date: November 16th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11209531/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Implementation of a Multidisciplinary, Pre-intubation Airway Checklist at a Level 1 Trauma Center

Tianyu Tang, MD, MS[1], Newton Addo, Bsc[1], Elizabeth Liu, MD[1,2], Justin Teng, MD[1,3], Matthew Roces, MD[1,4], Joseph Brown, MD[1,5], Kayla Enriquez, MD, MPH[1]

[1] University of California San Francisco, San Francisco, CA
[2] Alameda Health Systems Highland Hospital, Oakland, CA
[3] Kaiser Permanente South Sacramento, Sacramento, CA
[4] University of California Los Angeles, Los Angeles, CA
[5] University of Colorado, Aurora, CO

Corresponding author: Tianyu Tang, MD, MS (Tianyu.Tang@ucsf.edu)

Abstract:

Background

Endotracheal intubation in the Emergency Department (ED) is a high-risk, yet vital procedure. With the goal of promoting patient safety and improving communication amongst team members, the SOLID Plan (Summarize, Optimize, Location, Identify, Drugs, and backup Plan) pre-intubation airway checklist was designed by Emergency Medicine (EM) and Anesthesia physicians and implemented at Zuckerberg San Francisco General (ZSFG) Hospital Emergency Department. This study aims to assess the effects of the SOLID Plan on complication rates, first-pass success rates, and the knowledge, attitudes, and perceptions (KAP) of airway management.

Methods

The SOLID Plan was created based on extensive literature review and feedback from providers involved in ED airway management. Prior to implementation, a survey was conducted examining KAP of the checklist. The SOLID Plan was then implemented for intubations, and data regarding its use, complications, and first-pass success rates were collected. A post-implementation survey was performed six months later.

Results

Rates of all complications decreased from 14.1% to 10.7% (p=0.09) after implementation of the SOLID Plan, though not all intubations utilized the checklist. When stratified for SOLID Plan use, there was no improvement in rates of complications. When adjusting for level of training of intubator, SOLID Plan use showed an improvement in first-pass success for all levels of training except PG-2s. Survey results demonstrated statistically significant improvement in perceived cooperation (p=0.015) and psychological safety amongst team members (p= <0.001).

Conclusions

SOLID Plan use did not result in statistically significant reductions in complication rates; however, there was increased odds of first pass success which is paramount to reducing adverse outcomes and optimizing patient safety. SOLID Plan also showed statistically significant improvement in feelings of psychological safety and actions performed that promote patient safety. Usage of a checklist should be maintained in the ED and may also have some utility in other settings.

Background:

Endotracheal intubation of patients in the Emergency Department (ED) is a high-risk, yet vital procedure performed by physicians caring for critically ill patients. Patients suffering from emergencies such as cardiac arrest, depressed mental status, airway obstruction, hypercarbia and hypoxia often need advanced airway management and intubation. The procedure itself is risky due to several factors including patient instability (as patients needing intubation are often critically ill), undifferentiated cause for presentation, high-pressure environment, time constraints, uncontrolled setting, and the need for coordination between specialists from different departments. Additionally, there are known peri-intubation complications such as hypotension, hypoxia, cardiac arrest, esophageal intubation, and direct airway injury (1) that can occur and increase patient morbidity and mortality. Lastly, the unpredictable environment in which patients require advanced airway management through endotracheal intubation in the ED, the success of the procedure, and mitigation of adverse events can be correlated to the experience of the intubating provider. Studies show improvement in first attempt success rates as training progressed with first attempt success defined as successful orotracheal intubation during initial laryngoscope insertion (2).

Proper airway management necessitates clear interdisciplinary communication and practice. Multiple specialties are usually involved in emergent endotracheal intubations including nursing staff, respiratory therapists, anesthesiologists, and of course, emergency physicians. Studies have shown that the use of video laryngoscopy (VL), practice simulations, and pre-prepared intubation kits and drugs can reduce the rates of associated complications in the peri-intubation setting. Various other studies have shown that using pre-intubation checklists can also reduce the risk of adverse effects, improve first-pass success rates, and ultimately improve patient outcomes (2, 3, 4, 5, 6).

Checklists have long been embraced in medicine as a systems-based approach to care delivery in which no two situations are ever exactly the same (8). Checklists ensure a list of action items, tasks, or behaviors is completed as a means to optimize care and reduce preventable errors (8). Standardized pre-intubation checklists are one method that have been increasingly used to address this need for patient safety optimization. In both ED and Intensive Care Unit (ICU) settings, several studies have shown that the implementation of pre-intubation checklists is associated with an increased first attempt success rate, reduced adverse events such as desaturations, and ultimately improved patient outcomes (9, 11).

Based on growing evidence of the benefits of pre-intubation checklists, the SOLID Plan (Summarize, Optimize, Location, Identify, Drugs, and backup Plan) airway checklist was designed and implemented by Emergency Medicine (EM) and Anesthesia physician collaboration at the Zuckerberg San Francisco General (ZSFG) Hospital. The SOLID Plan checklist was designed to streamline team communication, triage patients effectively, and plan for contingencies. The checklist begins with summarizing relevant case details, which includes pertinent medical history and reason for induction/intubation, then, hemodynamic assessment/stabilization and optimization of the patient. Location of next intervention is then determined (e.g. Operating room (OR) for immediate surgery vs ED for imaging or procedures) followed by identification of roles and responsibilities amongst team members. Lastly, the pre-intubation drug regimen and reasoning is discussed, followed by a contingency plan in the event the first intubation attempt is unsuccessful. This checklist addresses vulnerable points in advance airway management to ensure patient safety and decrease adverse events.

Objectives:

With the goal of promoting patient safety and improving communication amongst team members, the SOLID Plan pre-intubation airway checklist was implemented at ZSFG Hospital Emergency Department, San Francisco's only Level One trauma center. The SOLID Plan checklist consists of "Summarize, Optimize, Location, Identify, Drugs, and back-up Plan" in regard to endotracheal intubation. This study aims to assess complication rates (both major and minor), first-pass success rates with variance based on level of training, and

the knowledge, attitudes, and perceptions (KAP) of airway management team members about the checklist pre- and post-implementation. Findings of this study may promote use of airway checklists prior to intubation as a universal protocol, as well as in other departments, such as the ICU and on hospital wards.

Methods:

The SOLID Plan pre-intubation airway checklist was developed as a joint effort by physicians in the Emergency Medicine and Anesthesia departments at ZSFG to improve multidisciplinary communication during airway management and to decrease the rate of peri-intubation complications. The checklist was created based on an extensive literature review as well as feedback from a survey sent out to all providers potentially involved in airway management in the ED including ED physicians, anesthesiologists, CRNA's, ED nurses, respiratory therapists, and trauma surgeons. Prior to checklist implementation, all involved providers were messaged about the checklist via email, ED huddles, departmental updates, faculty meetings, and residency conferences. Signs with the SOLID Plan were posted throughout the ED Resuscitation area and on all video laryngoscopy towers in the ED. Compliance with SOLID Plan use during intubation was documented in the ED Physician Procedure Note, however a response to the question was not required.

A retrospective chart review of all patients requiring intubation in the emergency department at ZSFG from January 2020-December 2021 was conducted. The SOLID Plan was implemented in January 2021. All patients presenting to the ED requiring a definitive airway were included in the study. Monthly reports from Epic were pulled based on the presence of patient intubation procedure notes and trauma code or medical code chart documentation. Patient charts were then individually reviewed by members of the research team and if definitive airway management via endotracheal intubation was attempted in the ED, the patient was included in the study. Information on patient demographics, airway physician demographics, number of airway attempts, major and minor complications, airway medications, mortality and airway checklist use (once implemented) were collected from every patient chart. All statistical analyses were performed using R, version 4.0 (R Foundation for Statistical Computing). Baseline demographic and clinical characteristics of patients were presented as frequencies and proportions for categorical variables. All data was securely collected and managed via password protected Excel Workbooks and on UCSF My Research (University of California San Francisco, San Francisco, CA).

<u>Complications:</u>

Several peri-intubation complications were evaluated during chart review. Complications were divided into 2 categories, major and minor, as defined by the NEAR study. (2, 3, 5, 11, 12, 13, 14) Major complications were defined as death due to airway management (cardiac arrest or pulseless electrical activity (PEA) arrest), failed airway, esophageal intubation with delayed recognition, failed airway, and a dislodged tube that goes unnoticed. Minor complications were defined as hypotension (blood pressure dropping below 90/60) within 60 minutes of intubation requiring vasopressors or intravenous fluids (IVF), hypoxia, direct airway injury, esophageal intubation with immediate recognition, dental trauma, vomiting with aspiration, laryngospasm, and mainstem intubation with delayed recognition (not identified on initial chest x-ray). Rates of these complications were recorded and compared pre- vs post- SOLID Plan implementation.

<u>First Pass Success:</u>

Multiple variables and outcomes were evaluated pre- and post-checklist implementation, including training level of intubating physician and intubation first pass success rate defined as successful orotracheal intubation during initial laryngoscope insertion (2). Categorical data was analyzed using chi-square or fisher's exact test. Odds of first past success were assessed with logistic regression. First pass success rate was sub-categorized and further correlated to training level of intubating physician.

<u>Knowledge, Attitudes, and Perceptions (KAP):</u>

Prior to checklist implementation, a survey was conducted which examined knowledge, attitude, and perceptions of staff, nursing, advanced practitioners and physicians involved in the multidisciplinary approach of airway management in the ED. The survey included providers at all levels of training from anesthesia,

trauma surgery, emergency medicine, nursing, and respiratory therapy. The checklist was then introduced for all patients undergoing endotracheal intubation, and data regarding its use was collected. A post-implementation KAP survey was carried out six months later to evaluate improvements in multidisciplinary approach. Analysis of survey data was performed using chi-square or fisher's exact tests, with a p-value of <0.05 defined as showing statistical significance.

Results:

A total of 1090 patients, 559 in 2020 and 531 in 2021, were included in the study. Patient demographics can be found in Table 1. Patient distribution across all age groups by year was evenly distributed while nearly 2.5 as many females as males underwent intubation in both years (Table 1). A majority of patients requiring intubation (60.0%) were >/= 50 years old while very few pediatric patients were included in the study, 1.7% (Table 1). The most common comorbidities were found to be hypertension and substance use (Appendix 1). Indication for intubation was broken down into 6 categories with airway protection being the most common at 41.8% (Appendix 2). The SOLID Plan Airway Checklist was completed in 266 intubations in 2021 (50%), not utilized in 185 intubations (35%), and its use was unknown in 80 patients due to missing documentation (15%).

Table 1: Patient demographics

	Overall	**Year 2020**	**Year 2021**
Total	n=1090	559	531
AGE			
0 - 4	4 (0.4%)	4 (0.7%)	0 (0%)
5 - 17	14 (1.3%)	8 (1.4%)	6 (1.1%)
18 - 34	199 (18%)	101 (18%)	98 (18%)
35 - 49	214 (20%)	108 (19%)	106 (20%)
50 - 64	282 (26%)	139 (25%)	143 (27%)
65 - 84	282 (26%)	145 (26%)	137 (26%)
85+	94 (8.6%)	54 (9.7%)	40 (7.5%)
NA	1 (<0.1%)	0 (0%)	1 (0.2%)
SEX			
Male	314 (29%)	161 (29%)	153 (29%)
Female	772 (71%)	397 (71%)	375 (71%)
Other	4 (0.4%)	1 (0.2%)	3 (0.6%)
SERVICE			
Adult Medical	697 (64%)	354 (63%)	343 (65%)
Adult Trauma	377 (35%)	192 (34%)	185 (35%)
Pediatric (Medical and Trauma)	16 (1.6%)	13 (2%)	3 (0.6%)

Complications:

Several peri-intubation complications were evaluated during chart review based on major and minor complications, as previously defined in the literature (Appendix 3). The most common complication pre- and post- SOLID Plan implementation was hypotension within 60 minutes of intubation requiring pressors or IVF (9.2%, n=101) (Appendix 3). When looking at the rate of all complications (major and minor) pre- and post-implementation of the SOLID Plan, the overall percentage decreased from 14.1% in 2020 to 10.7% in 2021 (p=0.09). When breaking down complications by major and minor, the rate of major complications decreased from 1.51% to 0.89% (p=0.41), while the rate of minor complications decreased, 13.06% to 9.23% (p=0.045) post SOLID Plan implementation.

The rate of overall complications in 2021 were further stratified by SOLID Plan Airway Checklist use as not all intubations utilized the SOLID Plan. Use of the SOLID Plan did not result in an overall decrease in the rate of complications but rather a slight increase of 1.8% in complication rate was found, although not statistically significant (Binomial CI -1.8 to 6.3%, p-value 0.49).

Rate of overall complications was stratified by the level of training of the intubating physician regardless of SOLID Plan usage (Table 2). Post graduate year 1 (PGY1) residents had the highest rate of complications (18.18%) while PGY2 residents had the lowest rate of complications (10.34%) as well as the highest number of intubations, 319 out of 1001 (30%).

Table 2: Overall Complication Rates by Level of Training of the Intubating Physician

Level of Training	**Complication Rate % (n/N)**	**Major Complication Rate**	**Minor Complication Rate**
PGY1	18.18 (6/33)	3.03	15.15
PGY2	10.34 (33/319)	1.25	8.78
PGY3	12.21 (37/303)	0.66	11.20
PGY4	13.67 (41/300)	1.00	13.00
Fellow-Attending	13.83 (13/94)	3.19	10.64
NA	14.63 (6/41)	0.00	14.63

Further stratification was done to assess how use of SOLID Plan and level of training of the intubating physician correlated with complication rates (Table 3). When comparing these numbers to overall complication rates, SOLID Plan usage decreased complication rates amongst all levels of training. Overall, PGY4's had the lowest rate of complications (7.8%, p=0.3) when using the SOLID Plan Airway Checklist (Table 3).

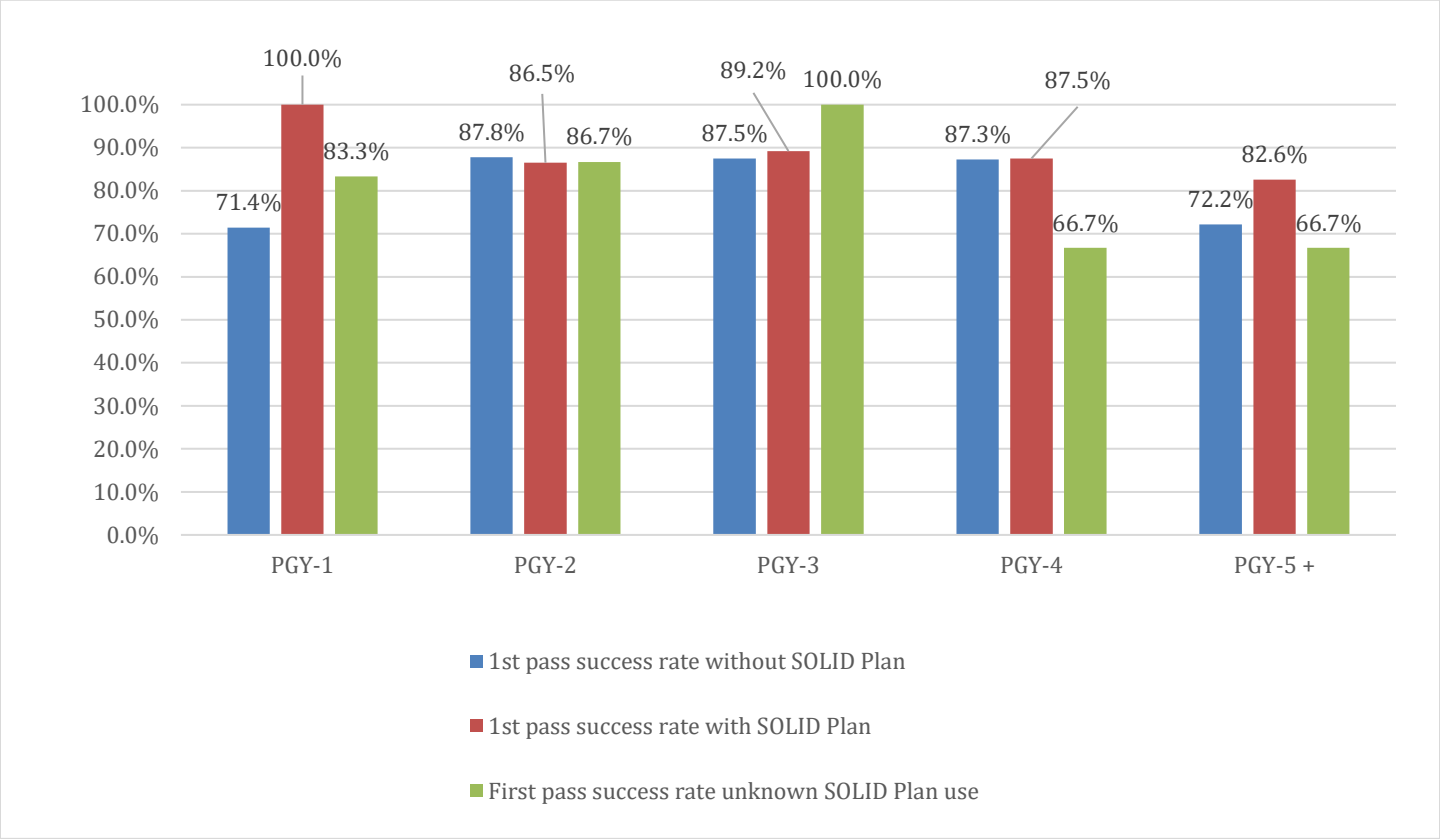
Table 3: Complications by training level with Solid Plan Use in 2021 (N= 266)

Training Level	**n Intubations**	**n Complicated**	**Complication Rate**	**Major Complication Rate**	**Minor Complication Rate**
PGY1	9	1	11.1	0.0	11.1
PGY2	96	10	10.4	1.0	9.4
PGY3	74	10	13.5	1.4	12.2
PGY4	64	5	7.8	1.6	6.2
Fellow-Attending	23	5	21.7	4.3	17.4

First Pass Success:

Of all intubations performed in the ZSFG emergency department, 88% (493/559) were successful on first pass in 2020, while 86% (455/531) were successful on first pass in 2021 after SOLID Plan implementation. When adjusting first pass success rate by level of training of intubating physician, no effect was detected and there was no change in first pass success rate when comparing 2021 vs 2020 (p = 0.16) (Appendix 4) when subcategorized by level of training. When adjusting first pass success rate for SOLID Plan use, there was no association with increased odds of overall first pass success rate in 2021 (OR 1.17, 0.69-1.96 95%CI, p = 0.55) Evaluation of first pass success rate when adjusting for level of training of intubator and SOLID Plan use in 2021 showed an improvement in all levels of training with exception to post graduate year 2 (Graph 1).

Graph 1: First pass Success rate by level of training with and without SOLID Plan use in 2021

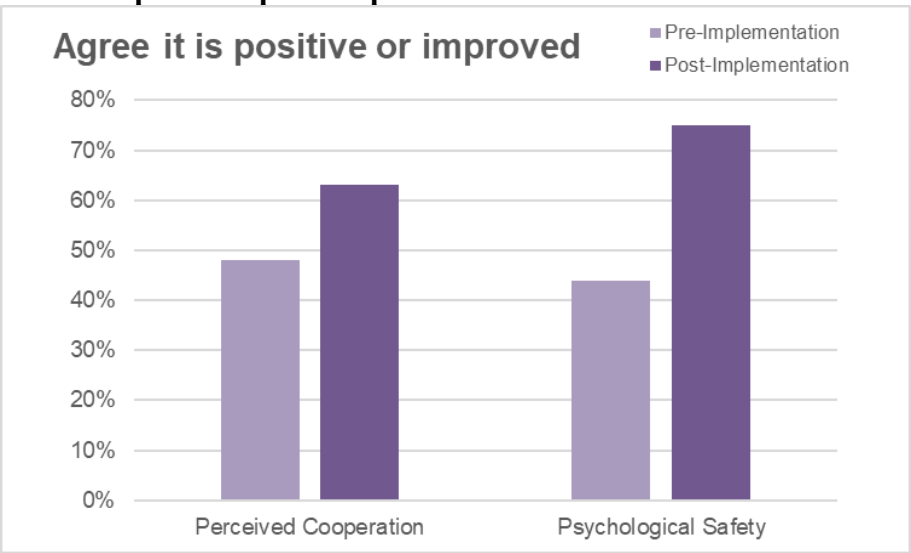


Knowledge, Attitudes, and Perceptions (KAP):

There were a total of 147 respondents for the pre-implementation survey and 97 for the post.

Survey results demonstrated statistically significant improvement in perceived cooperation (p-value 0.015 with 14% increase in moderately and extremely positive responses) and psychological safety among team members (p-value <0.001 with 31% increase in agree and strongly agree responses).

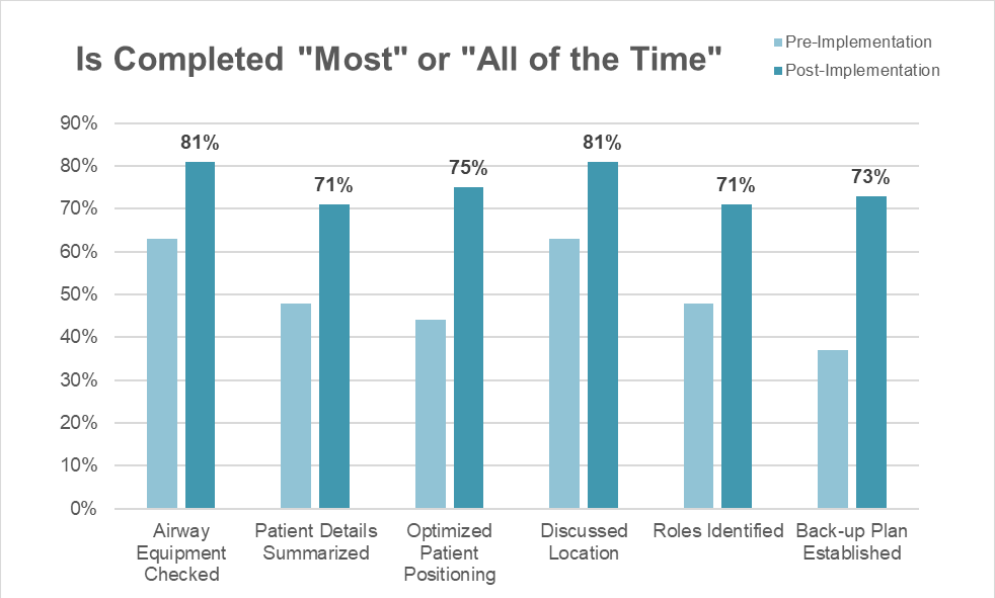
Graph 2: KAP Survey results around perceived cooperation and psychological safety among team members pre- and post- implementation



In terms of patient care, results showed that when utilizing a pre-intubation checklist, providers reported more frequent actions that promote patient safety, particularly actions that are highly variable and patient dependent. These such actions include checking airway equipment and making sure it is ready (p-value <0.001 with 34.8%

increase in most of the time and always responses), summarization of patient details (p-value 0.005 with 23.7% increase in most of the time and always responses), patient optimization in terms of positioning, resuscitation, etc. (p-value <0.001 with 30.9% increase in most of the time and always responses), discussion of location of intubation as either in the ED or OR (p-value 0.001 with 20.8% increase in most of the time and always responses), and establishment of a back-up plan such as LMA or surgical airway (<0.001 with 32.6% increase in most of the time and always responses).

Graph 3: KAP Survey results reporting actions that promote patient safety pre- and post-implementation



Follow-up:

Information on all patients presenting to the ED requiring a definitive airway continues to be collected at ZSFG Hospital for quality assurance review, performance improvement initiatives and patient safety. Data from January 1st, 2022-December 31st, 2025 was analyzed to look at retention of use of the SOLID Plan checklist, first pass success rate and rate of complications. (Table 4)

Table 4: Pre-implementation data vs 5 years of post-implementation data

	All Intubations	Documented Solid Plan Use, n (%)	First Pass Success Rate (%)	Complication, n (%)	Major Complication, n (%)	Minor Complication, n (%)
2020	N = 559		493 (88.2%)	79 (14.1%)	5 (0.9%)	73 (13%)
2021	N = 531	266 (50%)	455 (85.7%)	57 (10.7%)	8 (1.5%)	49 (9.2%)
2022	N = 422	333 (79%)	344 (81.5%)	44 (10.4%)	4 (1%)	38 (9.0%)
2023	N = 392	328 (84%)	323 (82.4%)	50 (12.8%)	9 (2.3%)	41 (10%)
2024	N = 447	400 (89%)	394 (88%)	42 (9.4%)	3 (0.6%)	41 (9.2%)
2025	N = 436	388 (89%)	380 (87.2)	51 (11.7%)	5 (1.1%)	46 (11%)
	p - value	<0.001	0.009	0.2	0.4	0.2

Solid Plan checklist compliance increased significantly from 2021 to 2025 and has remained stable at 89% use since 2024 (p <0.001). First pass success rate has averaged 84.96% (81.5% - 88%) since checklist implementation, down from the 88.2% average in 2020 prior to checklist implementation. Although not statistically significant, overall complication rate has remained lower than pre-checklist complication rate, at 10.6% average from 2021-2025 vs 11.6% average in 2020. While percentage of major complication rate was

similar in 2021-2025 at 1.3% compared to 2020 at 1.2% (p = 0.4), minor complications decreased from 13% to 9.6% (p = 0.2).

Overall, first pass success rate in relation to SOLID plan checklist use from 2021 to 2025 was 87% with use and 81% without use (p = 0.001). Overall complication rate in relation to SOLID plan checklist use from 2021 to 2025 was 12% with use and 8.9% without use (p = 0.09), with minor complications averaging 10% with and 7.3% without (p = 0.04) and major complications averaging 1.2% with and 1.8% without checklist use (p = 0.3). (Table 5)

Table 5: 2021-2025 First Pass Success Rate and Complication Rate in Relation to SOLID Plan

	Overall	**Documented Solid Plan Use**	**No Solid Plan Use**	**p-value**
	N = 2,223	N = 1,715	N = 508	
First Pass Success				0.001
First Pass Success	1,894 (85%)	1,484 (87%)	410 (81%)	
Unsuccessful or Multiple Attempts	329 (15%)	231 (13%)	98 (19%)	
Complication, n (%)				0.088
Yes	243 (11%)	198 (12%)	45 (8.9%)	
No	1,980 (89%)	1,517 (88%)	463 (91%)	
Major Complication, n (%)				0.3
Major Complication	29 (1.3%)	20 (1.2%)	9 (1.8%)	
No Major	2,194 (99%)	1,695 (99%)	499 (98%)	
Minor Complication, n (%)				0.041
Minor Complication	214 (9.6%)	177 (10%)	37 (7.3%)	
No Major	2,009 (90%)	1,538 (90%)	471 (93%)	

Limitations:

There were several limitations to our study. First-off, this study took place during the COVID-19 pandemic, where national emergency room visits and hospital admissions were at an all-time low. Secondly, given the retrospective nature of our data collection, our data is subject to the usual limitations associated with retrospective reviews such as data gaps, recall and selection bias, causation vs association and documentation variability. Another associated limitation is that the data we reviewed is often filled out by the person performing the intubation, so there is potential for underreporting complications and recall bias. We also did not have a steady or streamlined way of pulling reports that identified all intubations in the emergency department. We often had to review ED intubation procedure notes, trauma logs, and sometimes respiratory therapist notes and ED nursing notes to identify certain data points. Rarely, we also encounter small discrepancies between procedure notes when reviewing data.

Our analyses demonstrate that endotracheal intubation does not go without its risks. Although a majority of intubations are successful on the first attempt, we found there was still a notable proportion (22.7%) who had unsuccessful or multiple attempts, which may worsen patient outcomes. However, a percentage of this group may be a reflection of the severity of their illness rather than a direct consequence of the intubation itself. Remarkably, there was no statistically significant difference in first pass success rates when comparing level of training of the intubating physician. This can be attributed to a combination of factors. First, there was an uneven distribution of endotracheal intubations, with PGY-2, PGY-3 and PGY-4 performing the majority of procedures. The low number of intubations performed by PGY1 residents (n=11) and fellows/attendings (n=94) may make sizable differences difficult to infer. Second, the predicted difficulty of airways and subsequent allocation to appropriate level of training is not clearly documented. For example, patients with certain

indications for intubation or comorbidities may inherently have a lower likelihood of a successful intubation on first attempt. Therefore, these more difficult cases may be assigned to physicians with more experience (fellows and attending physicians) in order to improve patient safety.

While we did find a small reduction in first pass success rates when adjusting for level of training in 2021 compared to 2020, there are some limitations to this finding. Most notably, this analysis includes intubations where the documentation of the SOLID Plan was unknown. While a majority of intubations after January 2021 (when the checklist was implemented) documented whether or not the checklist was used, there were still a marked proportion of cases that were unknown. Because of these findings, further analysis was done to better understand the relationship between SOLID Plan use and first pass success rates by intubator levels. After omitting intubations with unknown use of the SOLID Plan, we re-analyzed this association and found a statistically significant adjusted odds ratio [AOR (95% CI) = 5.4(3.5-8.6)] of first pass success when the SOLID Plan was implemented, which was our strongest piece of evidence to suggest the airway checklist had an impact. Additionally, there may have been a spillover effect influencing first pass success rates in the post-implementation time period. The checklist's mere presence, regardless of its actual implementation in a specific intubation procedure, could have had an unmeasured effect.

Another limitation is the temporality of training experience and the way in which our data was coded. While postgraduate training is specifically categorized by year (e.g. PGY1, PGY2, etc.), the experience and training of a resident physician is continuous. For example, a PGY2 at the beginning of their year may be more similar in experience to a PGY1, which may affect how first pass success rates are analyzed and interpreted.

Our findings are consistent with other studies that demonstrate the positive impact of airway checklists on first pass success rates and subsequent patient outcomes. There have been additional methods of improving patient safety in the peri-intubation setting, which were not implemented or analyzed in this study, but may be helpful adjuncts to the SOLID Plan airway checklist. One such quality improvement had a multipronged intervention which included standardized equipment, airway checklist, post-intubation team debriefing and multidisciplinary team training (16). Another crossover randomized control study showed that a structured airway kit and pre-prepared drugs significantly shortened peri-intubation times, reduced procedural errors and decreased cognitive load experienced by the intubating physician (17). A propensity score matched study concluded that intubation with video laryngoscopy was also associated with two times higher odds of first pass success (18).

Conclusions:

Emergency airway management is a critical skill set for practicing EM physicians. A multitude of specialties are often involved in this high-risk procedure, and thus clear communication and structure is key for successful endotracheal intubation. Overall, we found that our SOLID Plan Airway Checklist did not result in any statistically significant reductions in complication rates; however, there was an increased odds of first pass success which is paramount to reducing adverse outcomes and optimizing patient safety. After implementation of the SOLID Plan, there was also a statistically significant improvement in feeling of psychological safety for providers and actions performed that promote patient safety. Usage of such a checklist should thus be maintained in the ED and may also have some utility in other settings.

Declarations:

The authors received no financial support for the research.

The study was conducted in accordance with the principles of the Declaration of Helsinki. This study was reviewed and approved by the University of California San Francisco institutional review board (IRB# 21-34210) under an expedited review procedure.

Human Ethics and Consent to Participate declarations: not applicable

Appendix:

Appendix 1: Patient comorbidities

Comorbidities	n	%
Cardiac	625	26.27%
Pulmonary	170	7.15%
Neuro	216	9.08%
Vascular	34	1.43%
GI	108	4.54%
Renal/Uro	103	4.33%
Systemic	330	13.87%
Psych	369	15.51%
Other	133	5.59%
Unknown/none	291	12.23%
Total	2379	100.00%

Appendix 2: Indication for Intubation

Indication	n	%
Airway Protection	439	41.8
AMS	398	37.9
Cardiac Arrest	301	28.7
Hypoxia	125	11.9
Hypercarbia	34	3.2
Airway Obstruction	4	0.4

Appendix 3: Complications across all intubations

Complication	n	%
MAJOR		
PEA Arrest	7	0.6
Failed Airway	4	0.4
Esophageal Intubation- delayed recognition	2	0.2
MINOR		
Hypotension within 60 min requiring pressors or dropping below 90/60	101	9.2
Hypoxia	23	2.1

Direct airway injury	1	<0.1
Esophageal intubation- immediate recognition	2	0.2
Dental trauma	0	0
Vomit with aspiration	0	0
Laryngospasm	0	0
Mainstem Intubation with Delayed Recognition (not identified on initial CXR)	0	0

Appendix 4: First pass success rate by level of training and year (regardless of SOLID plan use)

Training Level	**First Pass Success Rate**	
	2020	2021
PGY1	11/11 (100%)	19/22 (86%)
PGY2	130/144 (90%)	152/175 (87%)
PGY3	152/168 (90%)	121/135 (90%)
PGY4	151 (170 (89%)	113/130 (87%)
Fellow-Attending	39/47 (83%)	36/47 (77%)

References

1. April MD, Schauer SG, Nikolla DA, et al. Association between multiple intubation attempts and complications during emergency department airway management: A national emergency airway registry study. The American Journal of Emergency Medicine. 2024;85:202-207. doi:10.1016/j.ajem.2024.09.014
2. Garcia, Samuel I et al. “First-Attempt Intubation Success Among Emergency Medicine Trainees by Laryngoscopic Device and Training Year: A National Emergency Airway Registry Study.” *Annals of emergency medicine* 81.6 (2023): 649–657. Web.
3. Sakles, John C., et al. "The importance of first pass success when performing orotracheal intubation in the emergency department." Academic Emergency Medicine 20.1 (2013): 71-78.
4. Mort, Thomas C. "Emergency tracheal intubation: complications associated with repeated laryngoscopic attempts." Anesthesia & Analgesia 99.2 (2004): 607-613.
5. Hasegawa, Kohei, et al. "Association between repeated intubation attempts and adverse events in emergency departments: an analysis of a multicenter prospective observational study." Annals of emergency medicine 60.6 (2012): 749-754.
6. Brown III, Calvin A., et al. "Techniques, success, and adverse events of emergency department adult intubations." Annals of emergency medicine 65.4 (2015): 363-370.
7. Chaparro, A., Keebler, J. R., Lazzara, E. H., & Diamond, A. (2019). Checklists: A Review of Their Origins, Benefits, and Current Uses as a Cognitive Aid in Medicine. *Ergonomics in Design: The Quarterly of Human Factors Applications*, *27*(2), 21-26.
8. Klingberg C, Kornhall D, Gryth D, Krüger AJ, Lossius HM, Gellerfors M. Checklists in pre-hospital advanced airway management. Acta Anaesthesiol Scand. 2020 Jan;64(1):124-130. doi: 10.1111/aas.13460. Epub 2019 Sep 9. PMID: 31436306.
9. Divatia JV, Khan PU, Myatra SN. Tracheal intubation in the ICU: Lifesaving or life threatening? Indian J Anaesth. 2011;55:470–5. doi: 10.4103/0019-5049.89872
10. Kerrey BT, Mittiga MR, Rinderknecht AS, Varadarajan KR, Dyas JR, Geis GL, Luria JW, Frey ME, Jablonski TE, Iyer SB. Reducing the incidence of oxyhaemoglobin desaturation during rapid sequence intubation in a paediatric emergency department. BMJ Qual Saf. 2015 Nov;24(11):709-17. doi: 10.1136/bmjqs-2014-003713. Epub 2015 Jul 16. PMID: 26183713.
11. Gladston DV, Pillai VS, K M JK. Intubation bundle: A prospective observational tertiary cancer centre study of clinical practice and adverse events of tracheal intubation out of operation theatre. North Clin Istanb. 2025 Aug 6;12(4):501-508. doi: 10.14744/nci.2024.93284. PMID: 41059417; PMCID: PMC12497899.
12. April MD, Arana A, Reynolds JC, et al. Peri-intubation cardiac arrest in the emergency department: a national emergency airway registry (Near) study. Resuscitation. 2021;162:403-411. doi:10.1016/j.resuscitation.2021.02.039
13. Ko BS, Ahn R, Ryoo SM, et al. Prevalence and outcomes of endotracheal intubation-related cardiac arrest in the ED. Am J Emerg Med 2015;33:1642 5.
14. Sakles JC, Laurin EG, Rantapaa AA, Panacek EA. Airway management in the Emergency Department: a one-year study of 610 tracheal intubations. Ann Emerg Med 1998;31:325 32.
15. Heffner AC, Swords DS, Neale MN, Jones AE. Incidence and factors associated with cardiac arrest complicating emergency airway management. Resuscitation 2013;84:1500 4
16. Long E, Cincotta DR, Grindlay J, Sabato S, Fauteux-Lamarre E, Beckerman D, Carroll T, Quinn N. A quality improvement initiative to increase the safety of pediatric emergency airway management. Paediatr Anaesth. 2017 Dec;27(12):1271-1277. doi: 10.1111/pan.13275. Epub 2017 Oct 24. PMID: 29063722.
17. Swinton P, Corfield AR, Moultrie C, Percival D, Proctor J, Sinclair N, Perkins ZB. Impact of drug and equipment preparation on pre-hospital emergency Anaesthesia (PHEA) procedural time, error rate and cognitive load. Scand J Trauma Resusc Emerg Med. 2018 Sep 21;26(1):82. doi: 10.1186/s13049-018-0549-3. PMID: 30241559; PMCID: PMC6150998.

18. Trent SA, Kaji AH, Carlson JN, McCormick T, Haukoos JS, Brown CA 3rd; National Emergency Airway Registry Investigators. Video Laryngoscopy Is Associated With First-Pass Success in Emergency Department Intubations for Trauma Patients: A Propensity Score Matched Analysis of the National Emergency Airway Registry. Ann Emerg Med. 2021 Dec;78(6):708-719. doi: 10.1016/j.annemergmed.2021.07.115. Epub 2021 Aug 18. PMID: 34417072.