Testing Quality of Airway Intervention Scoring Systems with Simulation Cases

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Introduction

Sedation is utilized in pediatric dentistry due to challenges of behavior management. It requires knowledge of airway management to prevent adverse events. It is prudent to utilize an airway scoring system that numerically qualifies airway intervention techniques in response to compromising airway events for QA review.

Our team devised an airway scoring system that assigns values based on management and intervention. Our system is currently in its 3rd iteration. **Figure 1** depicts an example that lists airway interventions and respective number grades. Components are circled and an overall score is assigned based on the most advanced intervention. Scores range between 1-10 with 1 being "worst" and 10 being "best." Though the system is in its 3rd iteration, the full spectrum of its components is yet to be tested.

Due to our case selection process eliminating high-risk patients from undergoing sedation, advanced interventions are rarely encountered in our clinic and so we've yet to test full utility of our airway score system. The aim of our study is to assess the quality of our airway scoring system by testing it in both our sedation cases but also by introducing simulation cases with advanced airway interventions such that the full spectrum of airway interventions are accounted for in our datasets.

Figure 1. Example of Airway Score Sheet with Each Component

PLEASE CIRCLE ALL COMPONENTS OF THE AIRWAY SCORE THAT OCCURRED DURING THE SIM VIDEO PRESENTATION

COMPONENT / EVENT	D	E	F	G	H
1) OXYGEN USE	NONE / 2L NC	ADDED	3-5L or ≥ 30% O2	6-10L ≥ 50% O2	10L+ 100 % O2 /
2) CHIN / JAW MANEUVERS	NONE	OCCASIONAL CHIN LIFT	REPEATED CHIN LIFT	FORCEFUL JAW THRUST	REPEATED FORCEFUL JAW THRUST
3) PROCEDURE COMPLETION	NO ISSUES	MOSTLY COMPLETE	PARTIAL COMPLETION	MINIMAL COMPLETION	CANCELLED / TRANSFER OUT
4) COUGH MANAGEMENT	NO COUGH ISSUES	PRE-DOSE GLYCO-PYRROLATE	SUCTION	GLYCO-PYRROLATE	EXTRA SEDATION FOR COUGH
5) INTRA-ORAL / ASSISTANCE	NO ISSUES	ADJUST	CHANGE	REMOVE	ATTENDING INTER-VENTION
6) AIRWAY MANEUVRES	NONE	REPOSITION HEAD	TONGUE PULL	ORAL / NASAL AIRWAY / BMV	UNPLANNED ETT / LMA
7) SEDATIVE USE & AIRWAY	NO CONCERNS	MILD STIMULATION / PAUSE SEDATION	PAINFUL STIM. / STOP SEDATION	DEEPER SEDATION LARYNGO-SPASM	SUX FOR LARYNGO-SPASM OR REVERSAL

Methods

We created 10 video SIM cases that involved the most advanced airway interventions generally not encountered in our clinic. We then presented the SIM cases to our team of 8 dental residents who used the airway scoring system to delineate the airway interventions and assign an overall score. A SIM case script example is shown in **Figure 2**. An airway intervention (Intubation) from a video SIM case is shown in **Figure 3**. The simulation cases were created to include all of the most advanced airway interventions. The severity of the airway event components were categorized with letters D-H with H being the most drastic option for each component. A summary of all SIM case interventions is listed in **Figure 4**.

Our previously collected 150 real-life sedation cases were also included for data analysis. Following data collection of the airway and individual component scores, statistical analyses were implemented to assess **a)** Inter-rater reliability for the overall score and the score components, **b)** Resident to computer score comparison, **c)** Inter-rater correlation for the 7 different components and 5 options, **d)** Correlation of the 7 components with the overall score, and **e)** The effect of adding the SIM results to the above analyses.

Figure 2. Example of Simulation Case including All Identified Interventions

SIM Air 7	SCORE	4

12 year old moderate oral, MIDAZOLAM 20 MG, and Intranasal DEXMEDETOMIDINE 15 MCG, procedure started. Isolite in place

I. Patient gagging/coughing with isolite and replaced with Bite block
II. Noisy breathing noted, saturation remains 98%
III. Coughing with water from drill, resulted in desaturation to 93%
IV. O2 nasal cannula 2L added, SAT return to 98%
V. 20 minutes into procedure, noisy breathing worse and SAT fall to 92%
VI. Oxygen increased to 5L
VII. Mild and painful stimulation no effect
VIII. Bite block adjusted with no benefit, SAT 90%
IX. Procedure paused,
X. Patient breathing obstructed
XI. No response to chin lift or forceful jaw thrust, SAT 86%, O2 increased to 10L
XII. Tongue pull performed by dentist
XIII. Saturation improves to 100%
XIV. Continued chin lift results in patent airway
XV. Procedure completed

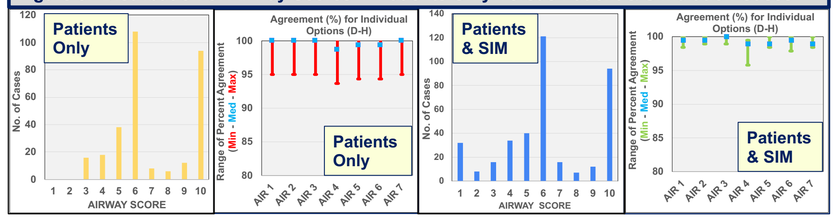
Figure 3. Screenshot from Simulation Airway Video

Figure 4. Table of All Components Included in Simulation Cases

NUMBER OF EACH COMPONENT during AIR SIM MODELS

	E	F	G	H
1) OXYGEN USE	4	10	4	3
2) CHIN / JAW MANEUVERS	2	9	4	3
3) PROCEDURE COMPLETION	3	3	2	4
4) COUGH MANAGEMENT	2	7	3	2
5) INTRA-ORAL DEVICES / ASSISTANCE	3	3	4	5
6) AIRWAY MANEUVERS	4	3	11	4
7) SEDATIVE USE AND AIRWAY	3	9	3	6

Figure 5. Distribution of Airway Scores in Patients Only Versus Patient & Simulation Cases



Results

A series of statistical analyses were used to assess all the data that was collected across the 150 real-life sedation cases and the 10 simulation cases. As illustrated in **Figure 5**, we showed the distribution of airway scores in our 150 simulation cases prior to the inclusion of the 10 simulation cases. The airway scores prior to the inclusion of the simulation cases ranged from 3-10 and did not include any cases that scored at 1 or 2, scores that would represent the most detrimental events that may occur during a sedation case. Also depicted is the percentage of agreement between raters as they selected for individual options among the tested seven airway components that make up the overall airway score.

Figure 6 shows the Cohen's Kappa scores calculated for each of the seven airway components and how well our team of residents measured up against the correct computer scoring. These values were distributed across three categories – real-life cases only, simulation cases only, and both groups together. This significantly improved the Spearman Ranks **(Figure 7)** that were calculated assessing the inter-rater correlation among our raters when scoring the overall Airway Score. These were calculated along two categories – (1) simulation cases only and (2) real-life cases & simulation cases combined. The Spearman Rank in both groups were very similar at 0.995 & 0.997.

The Cohen's Kappa scores were calculated for each of the seven airway scoring components making up the overall airway scoring system. As seen in **Figure 8**, the left graphic shows a distribution of Cohen's Kappa as calculated for the 150 real-life sedation cases. Note that some columns are missing as there was inadequate data to score for Cohen's Kappa in those categories that represent the most drastic airway interventions. Once the simulation cases were included, Cohen's Kappa was able to be calculated across the entire spectrum of the airway score components.

Finally, the Spearman Rank for each individual airway component within the score when compared to the Overall score was calculated. This was calculated prior to and after the inclusion of the simulation cases and can be visualized in **Figure 9** in the radar charts. The addition of the SIM cases shows all components are significantly correlated with the overall score ($p < 0.05$), mostly with a rank of assessment of strong (> 0.6).

Figure 6. Cohen's Kappa Scores for the Airway Component between Computer and Resident

KAPPA AIRWAY COMPUTER SCORE

	PATIENTS ONLY	SIM ONLY	PATIENTS & SIM
1) OXYGEN USE	1.000	0.966	0.996
2) CHIN / JAW MANEUVERS	0.997	0.997	0.998
3) PROCEDURE COMPLETION	1.000	0.978	0.995
4) COUGH MANAGEMENT	0.956	0.912	0.949
5) INTRA-ORAL DEVICES / ASSISTANCE	0.945	0.991	0.998
6) AIRWAY MANEUVERS	0.990	1.000	0.998
7) SEDATIVE USE AND AIRWAY	0.664	0.997	0.996

Figure 7. Spearman Rank Graphs for SIM Cases and Combined Real-Life & SIM Cases

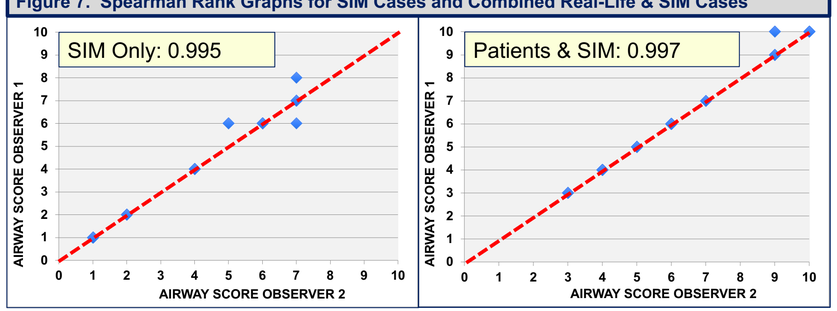


Figure 8. Distribution of Cohen's Kappa Scores for Patients Only and Simulation Cases Only

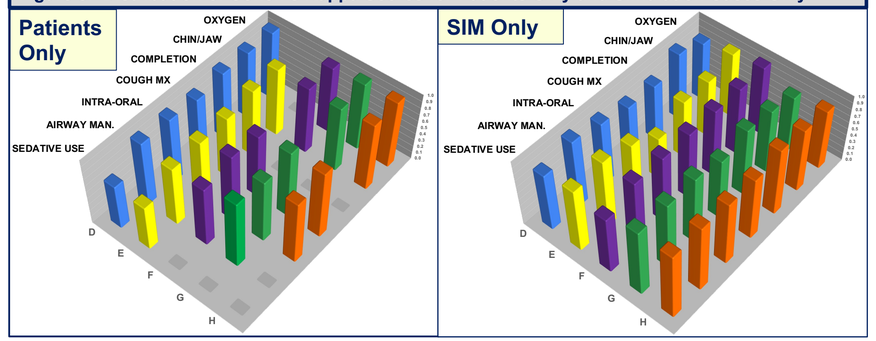
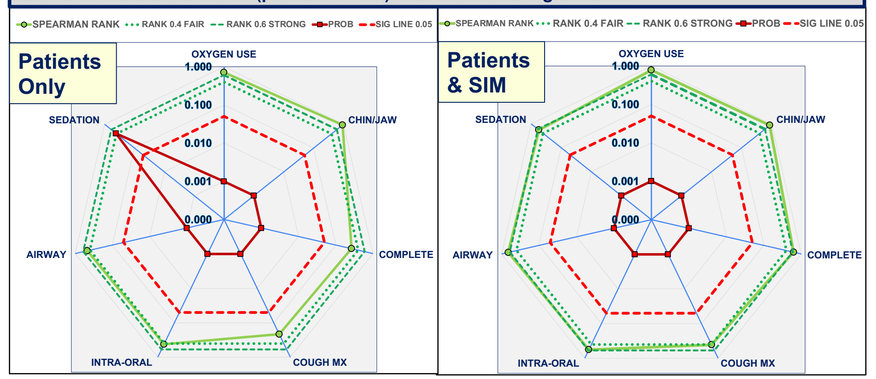


Figure 9. Spearman Ranks Calculated for Individual Airway Components Before (*patients only*) and After Simulation Cases (patients & SIM) with Statistical Significance



Discussion

Prior to the creation of the simulation cases, we had no data on how the airway scoring system would test against the most drastic airway events that are included in the score. This is illustrated in **Figure 5** where the distribution of airway scores do no include any scores of 1 or 2. Following the simulation cases, the range of distribution includes cases with scores of 1 and 2. The following statistical analyses can then assess for the full efficacy of the airway scoring system.

Spearman Ranks as calculated for the group of simulation cases only and the group of simulation and real-life cases combined were both valued at 0.995 and 0.997 respectively, which demonstrates a very strong correlation between pairs of airway observers when giving an overall airway score to the cases.

Within the overall airway score exists seven airway components – oxygen usage, chin/jaw maneuvers, procedure completion, cough management, intraoral device/assistance, airway maneuvers, and sedative usage. Each of these individual airway components had a Cohen's Kappa score calculated. Prior to to the creation of the simulation cases, Cohen's Kappa scores could not be calculated for some airway components due to a lack of real-life data which raised the question of whether our airway scoring system was fully effective in all the possible scenarios it accounts for. Following the simulation cases, Cohen's Kappa scores could be calculated for all individual airway component events.

Spearman Ranks were calculated for each of the seven airway components as well. Following the creation of the simulation cases, Spearman Ranks across all seven components showed improvement by rising. The Spearman Ranks were also found to all be statistically significant, demonstrating that our airway scoring system is in fact fully functional and comprehensive across the full spectrum of airway events that can be encountered in sedation dentistry.

The addition of the SIM cases showed similar score dispersal and the "missing gaps" have been filled in. We can now consider the Airway Score to be appropriate for clinical use as the inter-rater analysis is excellent for all levels of the score, all the component/options have been assessed and the components are correlated with the overall Airway Score.