

# Rapid Sequence Induction Practices In The United States And The United Kingdom: A Comparative Survey Study.

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## Abstract

### Purpose:

We aimed to survey the members of anesthesia departments in two large university hospitals, University of Washington (Seattle, USA) (UW-US) and University of Nottingham (Nottingham, UK) (UN-UK) to compare differences in their current approach to rapid sequence induction (RSI).

### Methods:

The survey was distributed in electronic and paper format in 2009. Overall response rate was 48.6% (146/300). Participants were asked to indicate their practice for a RSI technique for emergency appendectomy in a previously healthy adult. Data were summarized descriptively using frequency distribution. Chi square statistic was used to compare frequency of responses.

### Results:

There were several differences in the practice of RSI: 1. Aspiration prophylaxis was preferred in UW-US (40%) versus UN-UK (12%); 2. Preferred patient position was with a head support in UW-US versus 30° head of the bed elevation in UN-UK; 3. UW-US reported not to use mask ventilation prior to intubation (55%) versus UN-UK (78%); 4. The preferred opioid was fentanyl (93%) for UW-US and alfentanil (74%) for UN-UK; 5. Adjuvant drugs were used by 68% of UW-US versus 8% of UN-UK providers; 6. Commonly used induction agents were propofol in UW-US (94%) and thiopental in UN-UK (51%). Both centers preferred succinylcholine for muscle relaxation to rocuronium (UW-US 80% versus UN-UK 90%).

### Conclusions:

RSI practice differed significantly across continents. Due to disagreement and a lack of scientific evidence regarding the standards of RSI, it appears that traditional RSI practice has already been abolished. Revised evidence based guidance statement is due and has the potential to reduce practice variability.

## INTRODUCTION

Pulmonary aspiration is defined as the inhalation of oropharyngeal or gastric contents into the lower respiratory tract. Curtis Mendelson, an obstetrician, was the first physician to study the pathogenesis of the disease (Mendelson's Syndrome) using both case reports and animal experiments. Following contamination, lung epithelial cells and alveolar macrophages secrete chemical mediators, attracting and activating neutrophils, which in turn release proteases and reactive oxygen species, damaging the alveolar - capillary unit. Pneumonia, chemical pneumonitis and respiratory distress syndrome are possible adverse outcomes associated with significant morbidity and

mortality. The overall incidence of pulmonary aspiration of gastric contents during procedures undertaken with general anesthesia is estimated to be 1 in 2,000–3,000 cases. Aspiration is more frequent in emergency (1 in 600–900) than elective (1 in 3,000–4,000) procedures [1].

Rapid sequence induction (RSI) is commonly used to secure the airway in patients considered to be at risk of regurgitation and pulmonary aspiration of gastric contents. Stept and Safar originally published the 15-step RSI technique in 1970. The key elements of this technique should include the reduction of gastric volume, the control of acidity and passive movement of gastric content, the

minimization of time during which the airway is unprotected, and avoiding hypoxemia during attempts to secure the airways with tracheal intubation. All of these steps would appear to be logical and justifiable precautions. However, there has been debate over the understanding, the evidence base and clinical value of the individual components of this approach [1].

The apparent absence of compelling evidence poses challenges to both the modern practitioner and those responsible for training junior colleagues. It would seem reasonable to adopt and teach what is deemed to be “best practice” at regional, national or international level. Unfortunately a number of published surveys indicate significant variations in practice among anesthesia providers [2]. The purpose of this study was to describe the most utilized strategies to manage RSI and compare practice among university-affiliated hospital providers trained and practicing in different countries. The assessment of current practice is a useful basis for identifying the current standard of care.

## METHODS

Institutional review board approval was obtained under the exempt status from the University Washington Human Subjects Division. To identify potential ambiguities in the question design, four experts in the field, all members of the relevant institutions, pretested the survey instrument. All of the expert group’s feedback was considered and incorporated into the questionnaire.

After finalization, we distributed 300 anonymous survey questionnaires in electronic or paper form to a convenience sample of members of Departments of Anesthesiology at the University of Washington, Seattle, WA, USA (UW-US) and Nottingham University Hospitals NHS Trust, Nottingham, UK (UN-UK) in 2009. To increase the response rate monthly reminders were sent for three months starting one month after the initial distribution.

Participants were presented with a clinical scenario of emergency appendectomy in a previously healthy young adult and asked to indicate their practice of choice when considering a RSI technique for the induction of general anesthesia. The questionnaire consisted of 19 multiple-choice questions. Survey questions solicited provider information regarding antacid prophylaxis, use of nasogastric or orogastric tubes, patient positioning, modality of pre-oxygenation, application of cricoid pressure (CP),

administration of opioids, induction agents, muscle relaxants, adjuvant medications, and performance of facemask ventilation.

Data were summarized descriptively using frequency distribution. We conducted exploratory analyses comparing the frequency of responses between the two countries using the chi square statistic (test of homogeneity with n-1 degrees of freedom). A p-value less than 0.05 was considered statistically significant.

## RESULTS

Of the total 300 questionnaires distributed, 146 were returned, yielding an overall response proportion of 50%: 81 (54%) were returned at UW-US and 65 (43%) were returned at UN-UK. The characteristics of the responding providers were similar with regard to the level of training and clinical experience (Table 1).

**Figure 1**

Table 1 – Demographic description of study population.

	UW-US	UN-UK
	n=81	n=65
Grade, n (%)		
Attending/Consultant/SAS	34 (42)	28 (43)
Residents/SpR/ST/F2	29 (36)	37 (57)
CRNA	18 (22)	-

SAS; staff and associate specialist - UK, SpR; specialist registrar - UK, ST; specialty training -UK, F2; foundation year 2 - UK, CRNA; certified registered nurse anesthetists – US

## CHEMICAL ANTI-ACID PROPHYLAXIS AND HEAD POSITIONING

Aspiration prophylaxis was employed by 40% of UW-US providers, but only 12% of the UN-UK group (Table 2). UW-US providers favored sodium citrate (78%), H<sub>2</sub> receptor antagonists and proton pump inhibitors (47%), and metoclopramide (31%). Only a minority in both groups expressed support in favor of placing a nasogastric tube prior to RSI. Supine positioning with head support using pillow or gel ring differed between the two centers (UW-US 81% versus UN-UK 57%), as in the practice of head of the bed elevation (UW-US 37% versus UN-UK 63%).

**Figure 2**

Table 2 – Methods for Aspiration prophylaxis.\*

	UW-US	UN-UK	P-value
Aspiration prophylaxis, n (%)	32 (40)	8 (12)	<0.01
Choice of antacid, n (%)* (any)			
Sodium citrate	25 (78)	4 (50)	
PPI or H <sub>2</sub> -receptor antagonists	15 (47)	7 (88)	
Metoclopramide	10 (31)	2 (25)	
Nasogastric tube prior to RSI, n (%)	4 (5)	2 (3)	0.69
Head position, n (%)*			0.01
HOB elevated at 30 degrees	30 (37)	41 (63)	
Supine with support	66 (81)	37 (57)	
Other	6 (7)	3 (5)	

\* Percentages add up to more than 100% because categories are not mutually exclusive. PPI; proton pump inhibitors, HOB; head of bed.

## PREOXYGENATION AND VENTILATION PRIOR TO INTUBATION

Preoxygenation techniques were not significantly different ( $p = 0.86$ ) between UW-US and UN-UK providers.

Preoxygenation to a specific end tidal oxygen concentration goal was reported in 62% and 60% of UW-US and UN-UK providers, respectively (Table 3). The application of pre-oxygenation based on the delivery of 3 or 5 vital capacity breaths or a specific duration tidal breathing results also indicated similarities (UW-US 38% versus UN-UK 40%).

Facemask ventilation prior to tracheal intubation was considered acceptable in 45% of the UW-US group. However, only 22% of the UN-UK providers reported using such ventilation ( $p < 0.01$ ).

**Figure 3**

Table 3 – Comparison of pre-induction and pre-intubation components of RSI

	UW-US	UN-UK	P-value
	n=81	n=65	
Pre-oxygenation technique, n (%)			0.86
Tidal Volume or Vital Capacity breathing	31 (38)	26 (40)	
To pre-specified end tidal oxygen concentration	50 (62)	39 (60)	
Pre-intubation ventilation, n (%)			<0.01
Never	45 (55)	49 (78)	
Sometimes or Always	36 (45)	14 (22)	
CP, n (%)	70 (86)	63 (97)	0.03
I will request CP, n (%)	77 (95)	63 (97)	0.02
Before loss of consciousness	62 (81)	54 (86)	
After loss of consciousness	15 (19)	9 (14)	
Maximum force applied with CP, n (%)			0.41
10N	9 (11)	2 (3)	
20N	19 (23)	7 (11)	
30N	11 (14)	29 (45)	
40N	19 (23)	20 (31)	
Don't know	18 (22)	7 (11)	
Other	5 (6)	0	

CP; Cricoid Pressure, AA; Anaesthetic Assistant, N; newton

## APPLICATION OF CRICOID PRESSURE

Overall, 86% of UW-US providers and 97% of UN-UK providers reported using CP (Table 3). Both groups reported CP to be applied by an anesthesia assistant (AA) before the loss of consciousness. Regarding the proficiency of AA to apply CP, 25% of UN-UK group indicated AA to require no instruction regarding how to correctly perform CP application. In the UW-US setting, 11% of the respondents reported requiring instructions regarding the application of CP. Required force for the CP varied more widely for UW-US responders while UN-UK providers responded more frequently to apply forces of 30-40 N.

## INDUCTION AGENTS USED WITH RSI

Opioid usage at the time of induction was nearly 80% in both groups, although the specific opioid differed significantly between the institutions, with UW-US practitioners favoring fentanyl (93%) and UN-UK providers favoring alfentanil (74%) (Table 4).

Adjuvant drug use, e.g. lidocaine, esmolol and other agents differed substantially, with 68% of the UW-US group, compared to 8% of the UN-UK group, reporting to use adjuvant drugs. Among UW-US practitioners who responded using an adjuvant agent, all responded to use lidocaine.

Propofol was the by far the preferred choice (94%) of UW-US respondents. In contrast, sodium thiopental and propofol were almost equally preferred among the UN-UK providers as the induction agent of choice 51% versus 49% respectively. Speed of administration of induction agent was not different between groups, the majority reporting to administer it as a fast bolus.

Muscle relaxant preference did not differ between groups, with succinylcholine being most frequently the paralytic of choice (80% UW-US versus 90% UN-UK group).

#### Figure 4

Table 4 - Comparison of pharmacologic components of RSI.

	UW-US	UN-UK	p-value
Opioids at the time of induction, n (%)	69 (85)	50 (79)	0.38
Opioid of choice will be, n (%)			<0.01
Alfentanil	5 (7)	37 (74)	
Fentanyl/other	65 (93)	13 (26)	
Use of adjuvant drugs at induction*, n (%)	55 (68)	5 (8)	<0.01
Adjuvant drug of choice, n (%)			<0.01
Lidocaine	51 (100)	1 (20)	
Other	4 (7)	4 (80)	
Induction agent of choice, n (%)			<0.01
Thiopental	2 (2.5)	32 (51)	
Propofol	76 (94)	31 (49)	
Other	3 (3.5)	0	
Administration of induction agent, n (%)			0.47
Pre-calculated dose: fast bolus	71 (88)	50 (83)	
Slowly or titrated against clinical response	10 (12)	10 (17)	
Muscle relaxant of choice, n (%)			0.1
Succinylcholine	65 (80)	57 (90)	
Rocuronium	16 (20)	6 (10)	

\* Percentages add up to more than 100% because categories are not mutually exclusive.

## DISCUSSION

This survey aimed to identify the preferred RSI practices for a straightforward, standardized clinical scenario by anesthesia providers of varying experience and to compare these findings between similar level healthcare institutions in the US and UK. Our survey provides unique perspective because it is the first one to provide a comparison of RSI practices on two different university-affiliated hospitals in different continents. The results of this comparison, by providing baseline data on current practice, may help establishing more uniform standards for performing RSI and identify opportunities for improvement of care delivery especially in areas of controversy.

Our survey has a number of limitations that must be considered when interpreting the findings. First, the response proportion was 54% for UW-US and 43% for UN-UK

providers. A low response reduces confidence to generalize the conclusions and raises the concern for selection bias. However, in survey research, this response proportion is generally considered acceptable. Second, we found that the distribution of many responses was clustered around a country-specific practice pattern, possibly suggesting that selection bias has marginal influence in our results. Lastly, practice at two institutions may reflect the geographical and cultural patterns of the specific center, and may not be representative of practice at other sites. Our study indicated that there were differences in the employment of anti-acid prophylaxis, use of ventilation prior to intubation, modality of application of CP, opioid of choice at the time of induction, choice of adjuvant drugs, preference of anesthetic agent between the two centers. However, lack of use of nasogastric tube, positioning of the patient's head, preoxygenation technique, application of CP, force required for CP, use of opioid at the time of induction, speed of application of the induction agent and choice of muscle relaxant were similar.

Our results are consistent with previously published studies. Thwaites and colleagues surveyed RSI practices for caesarean delivery and reported considerable variation in the timing and application of cricoid pressure (CP), the choice and dose of drugs used and the timing of their administration. They found no relation between any of these aspects to either level of training of the anesthesiologists or experience of practice. They did identify the existence of "fast" or "slow" rapid sequence induction techniques in practice during their survey. Morris and Cook reported all practitioners in their survey used pre-oxygenation, although the technique employed varied. In terms of agents, we found that sodium thiopental and succinylcholine were the most widely used drugs for RSI. Most respondents routinely administered an opioid. A previous study indicated that opioids were frequently used for induction except in Caesarean sections [2]. A survey from Wales, UK [2] reported that propofol was substituted for thiopental frequently, while succinylcholine was deemed less interchangeable. Consultants were less likely than trainees to use a RSI, and were less likely to use the traditional combination of thiopental and succinylcholine. Trainees were more likely to use rocuronium as a muscle relaxant, and more likely to choose morphine if administering an opioid. Consistent with Thwaites' "slow" RSI, the majority of respondents indicated that they preferred titrating the dose of induction agent. Cricoid pressure was used universally but

the practice of its application varied widely. Several specific RSI components deserve brief detailed comments based on our findings.

## **CRICOID PRESSURE**

Application of CP, its effectiveness, and correct applications have all been challenged [3- 4]. New evidence shows that the alimentary canal at the level of cricoid ring is post-cricoid hypopharynx and not the esophagus [5]. Rice and colleagues define the concept of “cricoid pressure unit” and discredit the logic of effectiveness of the CP due to previously reported displacement of esophagus in relation to trachea [6]. Knowledge of appropriate amount of CP required is also important for successful intubation while providing best prevention from aspiration. Current recommendation is to apply 10 N when a patient is awake, and increase the force to 30 N once the patient loses consciousness. It appears that appropriately applied and carefully gauged CP will provide effective barrier against potential gastric regurgitation.

## **PREOXYGENATION**

Manual ventilation prior to tracheal intubation has been recommended in recent publications especially in specific group of patients such as obese, pregnant, pediatric and critically ill patients [7]. If the tracheal intubation attempt is unsuccessful, severe life-threatening hypoxemia can develop even before starting the failed intubation drill. Gentle mask ventilation (inspiratory pressure <20 cm H<sub>2</sub>O) before tracheal intubation is acceptable, if not mandatory, in these circumstances. There is no documented justification otherwise for routine use of manual ventilation prior to intubation. If difficult airway is anticipated, consideration should be given to awake fiberoptic intubation or regional anesthesia.

## **INDUCTION AGENTS**

There is a widely held view that the “gold standard” drug combination is thiopental and succinylcholine, which does have theoretical advantages for induction of anesthesia and rapid emergence and spontaneous ventilation in the event of an unexpected failed intubation. The use of the term “modified” RSI to describe anything other than the use of these drugs.

Unlike thiopental, propofol is suspended in a lipid medium, which allows for a high volume of distribution leading to a termination of action in 3 to 10 minutes (versus 4 to 15 minutes for thiopental) and elimination half-life of 4 to 7

hours (versus 18 hours for thiopental). Because of its shorter elimination half-life, propofol provides smoother emergence and faster recovery. In addition, propofol better suppresses laryngeal reflexes, it less likely produces laryngospasm and bronchospasm and is better tolerated by patients with asthma. Propofol has also some analgesic properties and can be effective in postoperative nausea and vomiting prophylaxis. These perceived advantages most likely explain the overwhelming preponderance of propofol in US practice where senior anesthesiologist provides immediate direction to other providers at all times.

## **NEUROMUSCULAR BLOCKERS**

Similar to previously conducted surveys [2] and a recent Cochrane Review comparing rocuronium to succinylcholine for RSI [8], our results indicate that succinylcholine continues to be the muscle relaxant of choice for RSI at both institutions. Current evidence suggests there are no statistical differences in intubation conditions when succinylcholine was compared to 1.2mg/kg rocuronium [8]. However, there are some contraindications to succinylcholine use, including allergy, malignant hyperthermia, denervation syndromes, and >24–48 h post burn, crush injury or hospitalization. The significant limitation of rocuronium in this setting includes its long duration of action with the potential delay in re-establishing spontaneous ventilation. On the other hand, adequate paralysis may be advantageous to facilitate attempts for further airway maneuvers compared with short-lasting muscle relaxation. With the use of succinylcholine premature recovering of airway reflexes may hinder effective airway management and increasing the chance of vomiting. In the hands of appropriately trained staff both agents perform adequately for RSI.

## **ADJUVANT MEDICATIONS**

Utilization of adjuvant therapeutics in RSI has also received variable acceptance over time. In our survey, it was interesting that US providers preferred fentanyl for their induction opioid. The goal of opioid administration at induction is to reduce cardiovascular responses to the stimulation of intubation the ideal induction opioid should be quick in onset, short in duration of action, and have high potency. When compared to alfentanil (preferred opioid of the UK providers) and remifentanyl, fentanyl performs poorly in this regard.

There was a significant difference between groups regarding the adjunctive use of lidocaine, which may have two



possible explanations. First at the time of the survey, UK providers had access to a newer formulation of propofol, Propofol-Lipuro® 1% (B. Braun, Melshungen AG, Germany) that consists of long- and medium-chain triglycerides that result in a smaller concentration of free propofol in the aqueous phase compared to previous formulations. US providers use Diprivan (Propofol 1%) APP (APP Pharmaceuticals, LLC, Schaumburg, IL), in a fat emulsion formulation consisting of soybean oil (long-chain triglycerides) and a larger concentration of free propofol in the aqueous phase in addition to preservative ethylenediaminetetraacetic acid (EDTA). When used for anesthetic induction, this formulation causes pain or discomfort on injection in 28%–90% of patients because large concentration of free propofol in the aqueous phase is related to pain on injection. In order to reduce the pain on injection lidocaine pretreatment is commonly utilized in various doses in the US. Second, lidocaine is reported to have anti-tussive effects and also attenuates induced tachycardia, hypertension and raised intracranial pressure associated with laryngoscopy and tracheal intubation [9]. Although it is still not clear how lidocaine produces these effects, its response has been shown to increase in a dose-dependent manner, and correlates well with plasma concentrations.

## ASPIRATION

Part of the variation in practice may be attributable to experience of practitioner in response to the specific conditions related to the pathophysiology of different patient groups. We are not aware of any study showing significant variation in the rates of aspiration associated with different positions in which RSI is used. Thirty degrees of trunk elevation was described originally; since then head up, head down and supine positions have all been advocated.

Recently published UK national survey identified the minimum number of events in relation to general anesthesia to be 46 per million, or approximately one per 22 000 anesthetics [10–11].

Aspiration of gastric contents was the primary event in 23 anesthesia cases, two emergency department cases, and no ICU cases. It was the most common cause of death in the anesthesia series accounting for eight deaths and two cases of brain damage. Aspiration occurred most frequently in patients with risk factors, at induction of anesthesia or during airway instrumentation. During the review of these cases investigators reported that some patients did not receive RSI

management or aspiration prophylaxis.

Along with the previously published French and US studies aspiration was the single most common primary cause of fatality (primary event in 50% of deaths) in anesthesia related events. Aspiration is a cause of litigation in about 10–15% of anesthesia airway-related claims in the US and the UK [12]. In the French study, aspiration was identified as the cause of death in 83 of 131 anesthesia-related deaths (63%) [13]. While the absolute incidence of such events is rare, these data emphasize the importance of aspiration as a major contributor to airway-related morbidity and mortality in anesthetic practice.

Our results indicate some substantial variation in many aspects of RSI between US and UK providers from that originally described - aspiration prophylaxis, preoxygenation, CP, 30° head up position, insertion of a nasogastric tube, rapid induction with a pre-determined dose of hypnotic agent and neuromuscular blocking agent, omission of manual ventilation, and intubation with a cuffed tracheal tube. Rapid sequence induction continues to be the preferred choice of securing airway of patients with high risk of aspiration.

Lack of agreement between the two units probably continues to be influenced by local practices and availability of resources rather than generalized scientific consensus. Until more robust evidence becomes available, these variations of RSI practices are likely to be perpetuated in anesthesia training programs. It is important to advocate thoughtful clinical practices with appropriate knowledge, skill and attitude to modify RSI to the unique clinical needs of individual patients and to seek appropriate senior support if such modifications are outside the bounds of familiar practice.

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