ORIGINAL ARTICLE

Airway Management with Leksell Frame in situ with or without Frontal Bar: A Mannequin Study

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ABSTRACT: ***Background:*** The use of stereotactic headframes for neurosurgical procedures requiring targeted localization continues to grow with new advancements in technology and treatment modalities. A configuration of the Leksell stereotactic G frame with a straight front bar, useful in epilepsy and laser cases, almost completely obscures oral access and presents a significant airway challenge for the anesthetist. Although previous papers have suggested that the entire headframe should be removed during an airway emergency, we describe a novel method to remove only the front bar. ***Methods:*** We performed an observational mannequin study. Anesthesia personnel from a single center were asked to intubate a mannequin with the Leksell frame fully in situ and again with the front bar removed. In addition, the time to remove the entire frame versus only the front bar was investigated. ***Results:*** Eighteen anesthesia personnel participated in the study as well as four neurosurgeons. The average time to intubate the mannequin in the frame was 23.5 (11.4) seconds and with the front bar removed, 10.9 (2.5) seconds ($p < 0.001$). The average time taken to remove just the front bar by the neurosurgeons was 35.4 (7.3) seconds compared to an average of 83.3 (18.6) seconds to remove the headframe entirely ($p < 0.001$). ***Conclusion:*** Our study demonstrates that intubating with the Leksell front bar in situ is possible with videolaryngoscopy under an ideal situation. More importantly, the removal of just the front bar is a simpler more streamlined approach requiring statistically less time to secure an airway.

RÉSUMÉ : Maintien de la perméabilité des voies respiratoires avec un cadre de Leksell en place, muni ou non de la barre frontale : étude sur mannequin. ***Contexte*** **:** Les cadres de stéréotaxie utilisés en neurochirurgie pour les interventions nécessitant une localisation ciblée ne cessent d'évoluer parallèlement aux progrès technologiques et aux nouvelles formes de traitement. Le cadre stéréotaxique de Leksell de type G, muni d'une barre frontale droite, est utile dans les cas d'épilepsie et d'intervention au laser, mais sa forme bloque presque complètement l'accès à la bouche et pose un sérieux problème de maintien de la perméabilité des voies respiratoires à l'anesthésiste. On suggérait, dans des études antérieures, de retirer tout le cadre d'immobilisation de la tête en cas d'urgence respiratoire, mais nous présenterons plutôt dans l'article une nouvelle façon de faire consistant dans le seul retrait de la barre frontale. ***Méthode*** **:** Il s'agit d'une étude d'observation monocentrique sur mannequin. Des anesthésistes de différentes catégories devaient intuber un mannequin après la mise en place d'un cadre complet de Leksell, puis procéder à la même manœuvre après le retrait de la seule barre frontale. A également été calculé le temps nécessaire au retrait du cadre complet, ainsi qu'à celui de la barre frontale seulement. ***Résultats*** **:** Au total, 18 anesthésistes et 4 neurochirurgiens ont participé à l'étude. Le temps nécessaire à l'intubation du mannequin avec le cadre de Leksell en place s'élevait en moyenne à 23,5 secondes (11,4) et celui sans la barre frontale, à 10,9 secondes (2,5) ($p < 0{,}001$). Quant au temps nécessaire aux neurochirurgiens pour retirer la barre frontale, il était en moyenne de 35,4 secondes (7,3) par rapport à 83,3 secondes (18,6) pour le cadre complet ($p < 0{,}001$). ***Conclusion*** **:** D'après les résultats de l'étude, il est possible de procéder à l'intubation d'un patient à l'aide d'un vidéolaryngoscope même si la barre frontale du cadre de Leksell est en place, dans des circonstances idéales, mais – point plus important encore – le retrait de la seule barre frontale est tout simplement plus rapide et nécessite statistiquement moins de temps que l'autre méthode pour assurer le maintien de la perméabilité des voies respiratoires.

Keywords: Stereotactic headframe, Airway management, Neurosurgery

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Introduction

Stereotactic headframes are often indicated in neurosurgical procedure requiring precise localization of target tissue such as deep brain stimulation, stereotactic radiosurgery, stereotactic electroencephalography (SEEG), and laser interstitial thermal therapy (LITT). However, airway management of patients with stereotactic headframes in situ poses a major challenge for the anesthesiologists. The stereotactic frame often obscures access to the mouth making bag mask ventilation impossible. In addition, head and neck manipulation is restricted making placement of a supraglottic airway, laryngoscopy, and intubation difficult. Currently, the literature on crisis airway management in stereotactic frames remains limited with no guidelines or consensus.

A previous mannequin study using a Leksell frame with a curved anterior bar demonstrated that intubation with both direct laryngoscopy (DL) and videolaryngoscopy (VL) as well as

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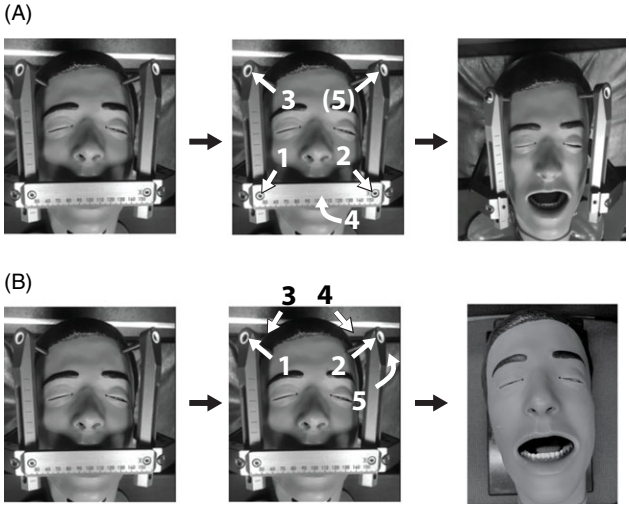

Figure 1: *Frame removal techniques. (A) In the front bar removal technique, the front bar screws are completely released (steps 1 and 2). One of the frontal pins is then unscrewed until it does not make contact with the skin (step 3) and the front bar is pulled (step 4). If the front bar cannot be removed at this stage because of persistent tension in the frame, the second frontal pin can be loosened (step 5, optional) as the front bar is being pulled, until it is released. (B) In the full frame removal technique, both frontal (steps 1 and 2) and posterior (steps 3 and 4) pins are completely loosened. The frame is then removed superiorly (step 5).*

insertion of a laryngeal mask airway (LMA) is possible with stereotactic headframe in situ.[1] However, previous case reports have reported potential problems associated with airway management including failed insertion of intubating laryngeal mask airway (iLMA) and esophageal perforation following multiple intubation attempts.[2,3] Therefore, it has always been suggested to keep an Allen wrench with the patient to remove the frame in emergency situations where intubation or LMA insertion is not successful.[3]

Recently, newer procedures such as SEEG and magnetic resonance imaging-guided laser interstitial thermal therapy (MRIgLITT) may require special configurations of the standard stereotactic frame (Leksell G series frame, Elekta, Stolkhom, Sweden). In such applications, a straight front bar may be required, which further restricts the access to the airway and makes airway management even more difficult (Figure 1). An additional concern is that many of these procedures require transfer of patients between different imaging and procedure locations where access to extra equipment and personnel may be a challenge. Bag mask ventilation would not be possible over the straight front bar; therefore, securing access in an airway emergency where LMA insertion or intubation has failed would require the removal of the frame. Removing the entire headframe may be time consuming and potentially complicated leading to catastrophic hypoxia and hypoventilation in patients with intracranial pathology during an airway crisis.

The objectives of this study are (1) to assess the difficulty of intubation with or without the front bar of a Leksell frame and (2) to determine the time taken for the removal of the front bar versus the whole frame.

Methods

Study Design – Prospective Observational Mannequin Study

The study was approved by the institutional research ethics board (20-6052) and informed consent was obtained from all participants. Participation was open to all members of the anesthesia staff within the department of anesthesia. The study also included members of the functional neurosurgical service at our institution, including fellows and consultants. Eighteen anesthesia personnel and four neurosurgeons participated in the study. Of the anesthesia participants, there were 3 residents, 11 fellows, and 4 consultants. The neurosurgical participants included three functional neurosurgical fellows and one consultant neurosurgeon.

Setup

The study was conducted in the functional neurosurgery operating room (OR). A Leksell model G frame was assembled by the functional neurosurgery fellow using two short posterior poles, two long anterior poles, and the straight front bar. The frame was installed on a mannequin using 42.5 mm screws posteriorly and 45 mm screws anteriorly, all torqued to 60 cNm. The frame was positioned parallel to the cantomeatal plane with the front bar inferior to the nose. The framed mannequin was then placed at the head of the OR bed in the standard position.

Interventions

Intubation with or without the front bar

Standard intubation equipment including a size 7.5 endotracheal tube (ETT), stylet, and CMAC® videolaryngoscope (Karl Storz Products, Tuttlingen, Germany) with a size #3 blade was placed on a Mayo stand next to the mannequin. Participants were allowed to adjust the height of the bed as well as the positioning of the CMAC® screen prior to data collection; however, no other modifications to the mannequin were permitted.

Participants were first asked to intubate the mannequin with the headframe in situ and front bar on a total of three times. They repeated this again with the front bar completely removed. Successful insertion was confirmed by visualizing the ETT pass through the mannequin's vocal cords and bilateral inflation of the lungs. If the participant was unable to intubate after three attempts, then it was considered unsuccessful.

Removal of the front bar versus removal of the whole frame

Neurosurgeons were timed removing just the front bar versus the entire headframe in the same setup. Removal of the front bar was achieved by removing both screws retaining the front bar and then completely removing one of the frontal pins and pulling on the front bar (Figure 1A). This decreased frame expansion allowed the front bar to be released. If the front bar could not be released at this stage, the second frontal pin was slowly unscrewed while the front bar was being pulled, until the front bar could be released. The other pins and frame were left in place. For the complete frame removal protocol, all four pins were completely unscrewed, and then the frame was pulled up to completely expose the head (Figure 1B). Both conditions were trialed three times.

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Table 1: Mean intubation times

	Residents ($n = 3$)	Fellows ($n = 11$)	Consultant ($n = 4$)	Total ($n = 18$)
Frame intact (seconds)	39.1 (21.0)	21.0 (17.0)	18.8 (6.9)	23.5 (17.4)
Front bar removed	14.2 (4.0)	10.4 (4.5)	10.0 (1.5)	10.9 (4.1)
p-values	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$

Table 2: Time to remove the entire frame versus front bar removal

	Entire frame	Front bar only	*p*-value
Time to remove frame	83.3 (18.6)	35.4 (7.3)	$p < 0.001$

Data Collection and Analysis

The required sample size was calculated using data from a previous study by Brockerville et al.[1] which reported an average intubation time using VL of 55 versus 45 seconds with and without headframe, respectively. Using a power of 0.8, an alpha of 0.05 with an expected drop out rate of 10%, a sample size of 18 participants was needed. Data collected from anesthesia participants included level of training and time taken to secure the airway. Time zero started when the participant picked up the CMAC® handle and time completed once the ETT passed through the cords. We also compared the times for each group (residents, fellows, and staff). For the neurosurgical participants, timing started when they touched the frame until frame manipulation was completed. The time to remove the headframe versus the front bar was compared. All data are presented as mean SD and statistics were performed using unpaired *t*-tests where a *p*-value < 0.05 was considered to be significant.

Results

All participants successfully intubated the mannequin using the CMAC® 3 blade with the Leksell frame intact and again with the front bar removed. Results for the airway study are shown in Table 1. The mean time for intubation was 23.5 (17.4) seconds with the front bar in situ. The average time for intubating with the front bar removed was significantly less at 10.9 (4.1) seconds ($p < 0.001$). The time required for intubation with the front bar removed is effectively decreased by half in this study with the effect being more pronounced with junior anesthesia staff.

The time taken to remove the front bar versus the entire frame by the neurosurgical participants is shown in Table 2. The mean time to remove the front bar was 35.4 (7.3) seconds compared to the time to remove the entire frame of 83.3 (18.6) seconds ($p < 0.001$).

Discussion

With the development of more sophisticated MRI thermometry,[4] techniques such as LITT are becoming much more prevalent. LITT has notable uses in neuro-oncology with the ability to treat recurrent gliomas, tumors in eloquent areas, and in patients with multiple metastases.[5–8] LITT is also useful in treating refractory epilepsy, patients with deep-seated epileptogenic foci, mesial temporal lobe epilepsy, hypothalamic hamartomas, tuberous sclerosis, and focal cortical dysplasia.[9,10]

Although very beneficial, this procedure also poses numerous difficulties for the anesthesiologist. As discussed previously, the use of the Leksell G series headframe with the straight bar provides unique challenges for airway manipulation. In addition, the LITT procedure in our institute involves several transfers out of the OR with the stereotactic headframe in situ. Although the majority of procedures are performed supine, LITT procedures may also require the lateral and prone positions increasing the inherent risk of losing the airway.[11] Although airway management with various other versions of the Leksell frame has been previously investigated using both an LMA or ETT, there has never been to our knowledge any investigations assessing airway management with G series frame where the straight front bar obscures oral access nor described this technique for rapidly removing the front bar on a Leksell headframe.

This study demonstrates that, contrary to a popular saying in the neurosurgical community, removal of the front bar without complete frame removal is possible if the tension in the frame is first decreased by the loosening of one pin (Figure 1). Removal of the front bar is a simple and faster procedure than removing the entire headframe and could be considered when improved access to airway is emergently required. Although this study demonstrates that intubating with the Leksell front bar in situ is possible with VL under ideal intubating conditions, most scenarios requiring emergency airway management in this headframe are unlikely to be under ideal intubating conditions as in our study, increasing the likelihood of failed intubation attempts. Therefore, statistically significant intubating times of 10 seconds faster with the front bar removed may translate into even greater clinical significance in a real airway crisis. In addition, the time taken to remove the front bar was 48 seconds faster on average than removing the entire frame. In addition, a simpler and more streamlined approach provides less opportunity for complications, errors, or injury to the patient or care provider. This study clearly demonstrates a rapid and simple method to improve intubating conditions by removing only the front bar.

Limitations

A major limitation of this study is that it was completed on a single mannequin with an uncomplicated airway, which does not replicate real life conditions. Although the headframe was placed by the functional neurosurgical fellow in the standard fashion, the positioning relative to the front bar may be slightly different on a person creating different intubating conditions. The difference in intubating times with the front bar removed is on average 10 seconds less than with the front bar in situ. The clinical significance of this can only be extrapolated in the context of an airway crisis with a rapidly deteriorating patient. In addition, the study did not specifically evaluate the time for insertion of an LMA or the difference in intubating times with DL versus with VL. We included participants with varying degrees of clinical experience especially in the context of neuroanesthesia. However, interestingly participants with the shortest time taken to intubate had the most clinical experience and may highlight the importance of training and experience when managing a difficult

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airway. We examined the stereotactic frame using only the straight bar setup as this likely proves the most challenging for securing a definitive airway; however, there are also a number of other configurations that were not specifically tested.

Conclusion

In conclusion, we have demonstrated that it is feasible and easier to remove only the frontal bar without removal of the entire frame to facilitate airway management. In addition, regardless of the level of experience, this method requires significantly less time compared to removing the entire frame. Therefore, removing only the front bar should be considered in an emergency situation to facilitate airway access using VL.

Statement of Authorship

TD contributed to experimental design, data acquisition, analysis, and manuscript. CIM contributed to the experimental design, data acquisition, analysis, and manuscript. SK contributed with experimental design and manuscript. LV contributed to manuscript and editing. MD contributed to experimental design, analysis, and manuscript.

Disclosures

The authors report no disclosures relevant to this manuscript.

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