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Istituto Neurologico Carlo Besta

Sistema Socio Sanitario
Regione Lombardia

# TRACCE PROVA ORALE

**CONCORSO PUBBLICO, PER TITOLI ED ESAMI, PER N. 1 POSTO DI DIRIGENTE MEDICO – AREA DELLA MEDICINA DIAGNOSTICA E DEI SERVIZI – DISCIPLINA DI ANESTESIA E RIANIMAZIONE – DA ASSEGNARE ALLA UOC TERAPIA INTENSIVA 1 – NEUROANESTESIA E RIANIMAZIONE**

## PROVA ESTRATTA:

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**CONCORSO PUBBLICO, PER TITOLI ED ESAMI, PER N. 1 POSTO DI DIRIGENTE MEDICO – AREA DELLA MEDICINA DIAGNOSTICA E DEI SERVIZI – DISCIPLINA DI ANESTESIA E RIANIMAZIONE – DA ASSEGNARE ALLA UOC TERAPIA INTENSIVA 1 – NEUROANESTESIA E RIANIMAZIONE**

## PROVA ORALE N. 2

FARMACI PER LA SEDAZIONE PEDIATRICA IN RISONANZA MAGNETICA

**QUESITO DI INGLESE:**

LETTURA E TRADUZIONE DI UNO STRALCIO DI ARTICOLO ALLEGATO.

**QUESITO DI INFORMATICA:**

IL CANDIDATO INDICHI COME TRASFORMARE DEI DATI IN UN GRAFICO.

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# Allegato prova orale n. 2

PROVA ORALE N. 2



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## Early transfusion and crystalloid infusion strategy in infants undergoing cranioplasty surgery

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Sir—Cranioplasty for craniosynostosis is a procedure associated with large incision of the vascular scalp and resection of the bone (1). This represents major surgery for young infants that have small blood volumes. The extensive blood loss requires transfusion of packed red cells in most patients (2). The exact determination of blood loss and fluid deficit in these procedures may be difficult because the absolute amount of shed blood is small although relatively high for the patient itself. Furthermore, 20–50% of the patient's blood volume may be lost in less than 30 min (3). Transfusion strategies currently developed are based on the acceptance of intraoperative level of hemoglobin (Hb) of 7 $g \cdot dl^{-1}$ and hemodilution [hematocrit (Hct) lower than 30] in absence of hemodynamic instability. We wish to describe our retrospective clinical study investigating the effectiveness of a preemptive transfusion and fluid management strategy.

From January1999 to September 2006, 66 surgical procedures were performed on children for the correction of a craniosynostosis in our hospital. In 2003, we introduced in our clinical practice early preemptive transfusion (Hb independent) and infusion (EPTI) strategy of homologous blood, fresh frozen plasma (FFP), and crystalloids. The main reason for adopting this new procedure was the clinical observation that the previous regimen of intraoperative hemodilution and late postoperative transfusions did not always replace the fluid and blood the infants needed. The new transfusion strategy was based on the estimate of the amount of blood losses occurring during earlier cranioplasties. This analysis showed that 50% of patients had intraoperative blood losses higher than 20% of estimated red cell volume (ERCV). Thus, in the EPTI strategy transfusion in every child was determined to be at least 20% of ERCV plus an amount of FFP equal to 1/3 of blood transfused. Infusion of at least 8 $ml \cdot kg^{-1} \cdot h^{-1}$ of crystalloid completed EPTI. This transfusion/infusion regimen began during the surgical phase of the coronal opening and was concluded at the milling and margining of the cranial vault. Additional volume was given as indicated by intraoperative assessment.

In 2006, we performed retrospective notes review to ascertain the outcome of children undergoing surgical correction of craniosynostosis treated with EPTI in comparison with those treated prior to the introduction of the new regimen (CONT group). The postoperative outcome measures considered were postoperative nihil-per-os time, ICU and in hospital postoperative length of stay (ICU-LOS, Total-LOS). Overall, 59 patients were studied, 25 in the CONT group and 34 in the EPTI group. Six children with incomplete data recording were excluded. There were no significant differences in demographic data, nature of skull deformation, preoperative Hct, Hb, clotting status, ERCV, and duration of surgery between the two groups. Scaphocefaly was the most frequent malformation. In the CONT group, 22 out of 25 infants were transfused (88%) while all 34 infants of EPTI received homologous blood. Median volumes of transfused homologous blood from a single donor, FFP, and crystalloids were all significantly higher during the intraoperative period in the EPTI group than in the CONT group: homologous blood, 135 (45–307) ml vs 0 (0–180) ml; frozen plasma, 100 (20–260) ml vs 0 (0–200) ml; and crystalloid, 721 (656–860) ml vs 435 (367–504) ml (data as median and 95% confidence intervals). After surgery, Hb and Hct were significatively higher in EPTI compared to the CONT group: 10.6 (10–11) $mg \cdot dl^{-1}$ and 31 (29–32) % vs 8.8 (7.8–9.8) $g \cdot dl^{-1}$ and 25 (23–28)%.

The EPTI group had significantly better outcome measures when compared to the CONT group. The relative risk for EPTI infants to receive a meal after 6 h compared to before 6 h was 0.06 (95% confidence intervals 0.02–0.23, $P < 0.001$); the relative risk to stay in ICU at least 1 day compared to no stay in ICU was 0.17 (95% confidence intervals 0.05–0.60, $P = 0.006$); and the relative risk to stay in hospital in the postoperative period more than 6 days compared to <6 days was 0.28 (95% confidence intervals 0.09–0.82, $P = 0.021$).

Our study has some limitations. It is a retrospective cohort, and we therefore cannot exclude the possibility that other events may have influenced the observed differences. It is also a small series with limited outcome measures, so we cannot make any comment about rarer complications. In conclusion, our results suggest that an aggressive and early strategy of intraoperative blood transfusion (EPTI) and crystalloid infusion may improve some outcomes in infants undergoing cranioplasty surgery.

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# PROVA NON ESTRATTA:

Allegato 1)

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## PROVA ORALE N. 1

GESTIONE DELL'EMORAGGIA NEI BAMBINI SOTTOPOSTI AD INTERVENTO DI CRANIOPLASTICA

**QUESITO DI INGLESE:**

LETTURA E TRADUZIONE DI UNO STRALCIO DI ARTICOLO ALLEGATO.

**QUESITO DI INFORMATICA:**

IL CANDIDATO INDICHI QUALI PROGRAMMI UTILIZZARE PER PREPARARE UNA PRESENTAZIONE IN CUI SIANO INCLUSE DELLE TABELLE STATISTICHE

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# Allegato prova orale n. 1



PROVA ORALE N. 1



## Response to 'Evaluation of the analgesia nociception index for monitoring intraoperative analgesia in children' (*Br J Anaesth* 2018; 121: 462–8)

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Editor—We have read with interest the study by Julien-Marsollier and colleagues[1] on analgesia nociception index (ANI) for monitoring intraoperative analgesia in children. Whilst the study appears well conducted, my colleagues and I had a few comments.

According to QUADAS-2 recommendations,[2] when investigating the diagnostic accuracy of a new test, the test under investigation is compared with a gold standard or reference test. One of the common design errors in studies of diagnostic accuracy is the use of an inappropriate gold standard or reference test. We believe that in this particular study, one of the methodological shortcomings relates to the lack of an appropriate gold standard. The ANI values were recorded for the same patients 5 min before and 5 min after surgical incision. The ANI values before incision were used as the reference standard against which ANI values post-incision were compared. This could introduce bias in the study. Therefore, the accuracy of the ANI as a diagnostic test for detecting noxious stimuli during surgery in anaesthetised children cannot be determined. There is no external validation of ANI. The area under the receiver operating characteristic (AUROC) curve values for ANI obtained in this study are similar to those for routinely recorded physiological variables, not ANI, from another study.[3]

We feel that an external, reference or gold standard should have been measured in this study in order to confirm that the changes seen in the ANI were due to the noxious stimulus being applied to the subjects.

### Declaration of interest

The authors declare that they have no conflicts of interest.

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## Cognitive re-engineering after a 15-year experience with routine videolaryngoscopy

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Editor—We read with interest the paper by Cook and colleagues[1] describing the structured introduction of the mandatory use of videolaryngoscopy across an entire department. Since 2003, we have mandated the use of videolaryngoscopy in the Department of Neuroanesthesia and Intensive Care of the Neurological Institute Carlo Besta of Milan (an academic tertiary care hospital with four operating theatres completing 2500 operations per year) where 14 staff anaesthesiologists perform 2000 routine videolaryngoscopic intubations per year. This policy arose from recognition of the increasing difficulties encountered during direct laryngoscopy, due both to patient factors such







as limited mouth opening and anaesthetist-related factors such as reduced muscle strength and age-related visual change.[2,3] These problems were exacerbated by the lack of a reliable assessment process that could reliably predict difficult intubation.[4]

In 2003, only two videolaryngoscopes were available: the Storz system which provided an improved view using a Macintosh blade or the Glidescope system which in addition to the improved view used a hyperangulated blade that we believed would reduce muscle fatigue. We chose to use the Glidescope and also mandated the use of an enhanced airway assessment protocol, the El Ganzouri Score or Simplified Airway Risk index.[5] This score includes the seven most common markers of difficult intubation to predict a difficult intubation. In 2010, after 6270 documented intubations it was shown to have an incidence of false negative scoring of 0.14%.[6,7]

In addition to the advantages cited by Cook and colleagues,[1] we believe that mandating videolaryngoscopy has further advantages: (i) a reduction in the physical workload involved[3]; (ii) repeatedly using the same equipment provides trainees with the prolonged repetitive practice required to gain expertise[6]; (iii) training requirements are reduced, in that new staff only need to be trained and assessed in one form of intubation; and (iv) an improvement in teamwork as a result of all staff using the same practice and because of a shared view of the airway. Despite the increased cost of videolaryngoscopy, we agree with Cook and colleagues[1] that this should be seen in the context of the human and financial costs associated with a failure to intubate/oxygenate.

We believe that the high success rate of direct laryngoscopy in routine practice provides many anaesthetists with a false sense of confidence, which leads them to continue with their own personal practice rather than embracing the benefits of working with colleagues to develop shared departmental standards.[8,9] Perhaps the retirement of a generation of anaesthetists trained before the introduction of videolaryngoscopy will provide us with the opportunity to change the way we work.

### Declaration of interest

The authors declare that they have no conflicts of interest.

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# PROVA NON ESTRATTA:

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## PROVA ORALE N. 3

VALUTAZIONE DELLA DISFAGIA IN PAZIENTI OPERATI IN FOSSA CRANICA POSTERIORE (NERVI CRANICI MISTI)

**QUESITO DI INGLESE:**

LETTURA E TRADUZIONE DI UNO STRALCIO DI ARTICOLO ALLEGATO.

**QUESITO DI INFORMATICA:**

IL CANDIDATO INDICHI I PROGRAMMI DA UTILIZZARE PER REPERIRE BIBLIOGRAFIE SCIENTIFICHE

# Allegato prova orale n. 3



PROVA ORALE N. 3

British Journal of Anaesthesia 112 (3): 563–9 (2014)
Advance Access publication 22 October 2013 · doi:10.1093/bja/aet347

BJA

RESPIRATION AND THE AIRWAY

## Upper limb muscular activity and perceived workload during laryngoscopy: comparison of Glidescope® and Macintosh laryngoscopy in manikin: an observational study

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### Editor's key points

- Muscle fatigue may interfere with performance during difficult laryngoscopy and tracheal intubation.
- In this study, objective and subjective workload were measured during tracheal intubation in a manikin using a Glidescope® or Macintosh laryngoscope.
- Muscular activity and perceived effort were both less when using the Glidescope®.
- Further data are required before extrapolating these data to clinical practice.

**Background.** The interaction between operators and their working environment during laryngoscopy is poorly understood. Numerous studies have focused on the forces applied to the patient's airway during laryngoscopy, but only a few authors have addressed operator muscle activity and workload. We tested whether different devices (Glidescope® and Macintosh) use different muscles and how these differences affect the perceived workload.

**Methods.** Ten staff anaesthetists performed three intubations with each device on a manikin. Surface electromyography was recorded for eight single muscles of the left upper limb. The NASA Task Load Index (TLX) was administered after each experimental session to evaluate perceived workload.

**Results.** A consistent reduction in muscular activation occurred with Glidescope® compared with Macintosh for all muscles tested (mean effect size $d$=3.28), and significant differences for the upper trapezius ($P$=0.002), anterior deltoid ($P$=0.001), posterior deltoid ($P$=0.000), and brachioradialis ($P$=0.001) were observed. The overall NASA-TLX workload score was significantly lower for Glidescope® than for Macintosh ($P$=0.006), and the factors of physical demand ($P$=0.008) and effort ($P$=0.006) decreased significantly.

**Conclusions.** Greater muscular activity and workload were observed with the Macintosh laryngoscope. Augmented vision and related postural adjustments related to using the Glidescope® may reduce activation of the operator's muscles and task workload.

**Keywords:** electromyography; intubation, tracheal; laryngoscopy; muscle fatigue, workload

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The ergonomics of laryngoscopy and tracheal intubation, which involve the physical interaction between the operator and the working environment (equipment) and the underlying psychological and cognitive elements responsible for such an interaction, are the subject of current research. Intubation is biomechanically defined as a complex multi-joint procedure that activates the operator's upper limb muscles during a short period of time.[1] The energy developed by muscles is transmitted to the patient's airway through the laryngoscope in the form of horizontal and perpendicular forces to expose the glottis.[2]

Successful laryngoscopy and intubation require a complex interaction between anatomical knowledge, physical strength, coordination, and visuospatial awareness,[3] which affects muscle utilization.[4]

Traditional direct laryngoscopy using the Macintosh laryngoscope blade requires line-of-sight alignment of the patient's mouth, pharynx, and larynx and adjustment of body posture to gain binocular vision and produce optimal lifting and pushing.[2 5–9]

In contrast, the Glidescope® videolaryngoscope, similar to other indirect visual procedures, has visual feedback separated from the operating field.[10] This allows the operator to achieve better visualization of the glottis and decreases the requirement for optimization manoeuvres (laryngoscope) and positioning efforts (posture).[11] All these factors contribute in reducing task workload, that is defined as the cost incurred by the operator to achieve a particular level of task performance.[12]

The induction phase (including intubation) is a period of high workload in anaesthesia clinical practice,[13] indicating that the







operator's cognitive resources are almost totally dedicated to the task and that the capacity to deal with additional information is impaired.[13 14] Cognitive overload has been recognized as a significant cause of error, which can result in patient morbidity and mortality during intubation.[14 15]

In addition, anaesthetists report a perception of less fatigue and better ease of use with the Glidescope®, but the components of perceived workload during laryngoscopy have not been clarified.[11 16]

During the last 30 yr, numerous investigators have studied the forces applied to manikins or the patient's airway during laryngoscopy,[2 5–7 17–20] but only a few researchers have focused on the operator's muscular activity and effort during direct and indirect laryngoscopy.[16 21]

To test the hypothesis that different devices use different muscles and how these differences could affect perceived workload, we quantified upper limb muscle activity in a team of anaesthetists with dynamic surface electromyography (SEMG) and evaluated their subjective workload with the NASA Task Load Index (TLX) questionnaire[12] during a Glidescope® and a Macintosh laryngoscopy.

### Methods

The study was approved by the Institutional Review Board (December 23, 2011) and participants gave written consent. The STROBE statement-checklist for reports of observational studies was followed.[22]

#### Materials for laryngoscopy

A Standard Heine™ (Heine Optotechnik, Munich, Germany) laryngoscope with a number 4 Macintosh blade was used for all direct laryngoscopies, and a GVL Glidescope® videolaryngoscope (Verathon® Medical, Bothell, WA, USA), with a number 4 re-usable adult blade was used for all indirect laryngoscopies.

The manikin used was a commercial airway training model BILL II (Ref. 30-18-000 VBM Medizintechnik GMBH,s D-72172 a.N. Germany), which is not sold for difficult airway training. Using a manikin, instead of a real clinical practice theatre, was necessary to create the appropriate standard conditions for assessing the two devices.

#### Set-up for laryngoscopy

The same manikin was used for all participants. It was placed on a trolley, and its height was set between the anaesthetist's xiphisternum and umbilicus and initially positioned in the sniffing position with a pillow under the head. However, each participant was free to adjust the position of the manikin before the task.[8]

A silicone-lubricated Covidien (IIC Mansfield, MA, USA) 7.5 mm tracheal tube reinforced with a malleable stylet was used for each laryngoscopy.

The time of laryngoscopy was calculated from blade insertion in the manikin mouth to blade removal. A failed intubation was defined either as an attempt lasting >60 s or if the tube was not found in the trachea at the end of the manoeuvre.[18]

A reflective marker was positioned on the manikin's nose to evaluate the beginning and end of the manoeuvre, and, therefore, SEMG data collection.

Marker position was acquired with a computerized video motion analysis system using five infrared cameras at 140 Hz (SMART-D, BTS Bioengineering, Milan, Italy) integrated with electromyography and two video cameras.

The motion capture system recorded and processed the location of the passive reflective markers placed on the manikin nose.

The assessors (an anaesthetist and a bioengineer) did not reveal the process of laryngoscopy to avoid bias.

#### Specific conditions during Macintosh laryngoscopy

Before the trials, participants were reminded of the correct posture during intubation and the more ergonomic handling of the laryngoscope.[8 9]

Participants could change the tube curvature before and during laryngoscopy. An assistant passed the tube during intubation to prevent the operators from diverting their gaze from the target.

#### Specific conditions during Glidescope® laryngoscopy

The screen was positioned in front of the operator at a distance of 0.6 m[10] such that the eyes, manikin, and screen were on the same axis and the operators did not have to rotate their eyes or head during laryngoscopy.

The tube was performed in a hockey stick shape (90°) with a malleable stylet, and an assistant passed the tube and removed the stylet when requested.

#### Electromyography

SEMG signals, synchronized with two digital video cameras (sample rate 25 Hz) on the sagittal and frontal planes, were recorded at 1000 Hz (BTS FreeEMG, BTS Bioengineering) for each of the following muscles: upper trapezius, pectoralis major, anterior deltoid, middle deltoid, posterior deltoid, biceps brachii, brachioradialis, and triceps brachii. Bipolar Ag/AgCl (Ambu A/S, Denmark) surface electrodes pairs with 10 mm diameter were placed with an inter-electrode distance of 10 mm along the centre of each muscle.[1] Electrode placements followed the indications for SEMG for the Non-Invasive Assessment of Muscles.[23] An SEMG data report was implemented using SMART analyser software (ver. 1.10.394.0; 2006 by BTS Bioengineering), structured with the analysed SEMG variables. SEMG references related to maximum isometric voluntary contractions (MIVC)[24] were performed in standard postures for each muscle before the experimental trials. The recorded signals were band-pass filtered at 5–250 Hz with a third-order Butterworth filter and the full wave was rectified. The SEMG amplitude values during intubation were normalized to the SEMG values measured during MIVC. We calculated the integral (area under the curve, AUC) of the averaged signal from each muscle observed during each task trial as index of muscular activity.[23]

### Task workload assessment

NASA-TLX is a multi-dimensional self-report rating scale providing an overall subjective workload score based on a weighted average of ratings on six dimensions: mental demands, physical demands, temporal demands, performance, effort, and frustration.[12] Mental, physical, and temporal demand are defined as demands imposed on the subject by the task, whereas performance, effort, and frustration are determined by the interaction of the subject with the task. NASA-TLX is divided into two parts. In the first part, participants must assign a weight to the six factors and, in the second part, they have to rate the factors on a visual scale ranging from low to high and from good to poor only for the factor of performance. The combination of these two is used to calculate the final overall workload score and the six factors' subscores. NASA-TLX was administered at the end of each experimental session, and every participant obtained separate scores for the Macintosh and Glidescope® videolaryngoscopes.

### Study design and data collection

Acquisitions were performed in a randomized sequence during two Macintosh and Glidescope® laryngoscopy sessions. Before all experimental trials, each anaesthetist performed a training session of 10 intubations per device to become familiar with the manikin and avoid any learning effect during the session. Data collection began with the anaesthetist in a standing position. Data acquisition started 5 s before and ended 5 s after the intubation. Three intubations were performed for each session, with a 1 min break between each session to assess data consistency. All data acquisitions were performed by the same operator to ensure reproducibility of the acquisition technique and prevent bias because of inter-operator variability. Subjects completed NASA-TLX at the end of each session. A psychologist, blinded to the individual test results, attended all participants as they completed the questionnaire.

### Outcomes and hypothesis

Our primary outcome was to analyse the upper limb SEMG muscular activity during laryngoscopy performed with the Glidescope® and Macintosh. We expected at least a mean 50% difference in muscular activation between the two techniques, as quantified by the AUC index. The secondary outcome was the perceived workload assessed with the NASA-TLX. We speculated that the global workload score would be lower for Glidescope® than for Macintosh laryngoscopy. Furthermore, we determined the mental, physical, or both factors that contributed to 'less perceived effort', as reported by the anaesthetists. The time of intubation and success rate served as control variables.

### Sample size

We performed an *a priori*, two-tailed *t*-test for matched pairs sample size analysis. Based on the literature and on our clinical experience, we expected a mean 50% difference in the primary outcome, which was the SEMG muscular activation. We set $\alpha$ at 0.006 (see the Data handling and statistics section) and $\beta$ at 0.80, and obtained 10 as the total sample size required.

### Data handling and statistics

The AUC electrical activity of each of the eight muscles was calculated for each trial, and the mean and standard deviation (SD) for each session were considered to represent the behaviour of the subjects during the different tasks. A total workload score and single score for each of the six workload factors were obtained from NASA-TLX, and means and SDs were calculated for the two experimental conditions. Data were analysed using SPSS ver. 17.0 (SPSS Inc., Chicago, IL, USA). A two-tailed Student's *t*-test for matched pairs was performed, with the significance level set at $P \leq 0.05$, and at $P \leq 0.006$ ($P=0.05/8$) for SEMG data analysis and $P \leq 0.008$ ($P=0.05/6$) for NASA-TLX subscales analysis, according to the Bonferroni correction for multiple comparisons.

## Results

The overall population comprised 13 anaesthetists; one was not eligible because he was newly hired, and two decided not to participate. Therefore, 10 staff anaesthetists [six males and four females; mean (SD) age 43.6 (11.5) yr] all experienced with Macintosh and Glidescope® (>200 routine intubations), participated in the study. No subject had a history of chronic musculoskeletal problems or any known neurological disorders.

The two different laryngoscopes did not affect the duration of the manoeuvre (mean difference 1.3 s; $P=0.14$) and no failed intubation was recorded. The mean electrical muscular activity (AUC) was lower during Glidescope® laryngoscopy than during Macintosh laryngoscopy for all muscles (Fig. 1). We found significant differences for the upper trapezius ($P=0.002$), anterior deltoid ($P=0.001$), posterior deltoid ($P=0.000$), and brachioradialis ($P=0.001$). No statistical significance was reached for the pectoralis major ($P=0.008$), middle deltoid ($P=0.007$), triceps brachii ($P=0.033$), or biceps ($P=0.49$). We also calculated the effect size (ES) for the differences in muscle activation. We found a mean ES of $d=3.28$, which was very large, with single ESs of $d=1.71-7.75$.

An example of the SEMG signals analysed during Macintosh and Glidescope® laryngoscopy is shown in Figure 2. The total perceived workload score was significantly lower for the Glidescope® than for Macintosh laryngoscopy ($P=0.006$). Moreover, the factors of mental demand, physical demand, effort, and frustration were higher for the Macintosh than for Glidescope® laryngoscopy, with significant differences in physical demand ($P=0.008$) and effort ($P=0.006$) (Fig. 3).

## Discussion

Laryngoscopy and intubation are complex tasks because of direct interaction between the operator, device, and patient where motor control, attention, precision, and time play key roles in operator workload determination. Previous analytic models have focused only on the device–patient/manikin interaction but failed to analyse the operator, on whom control of task execution depends.[5–7 17–20]





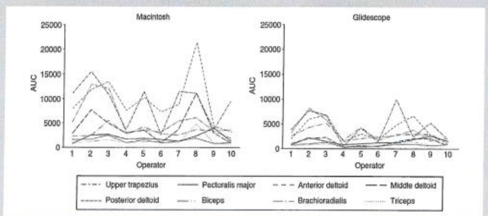


Fig 1 Mean muscular activity (area under the curve, AUC) of each operator muscle under the two experimental conditions (Macintosh and Glidescope®).

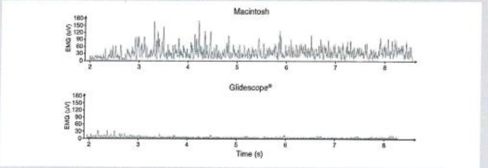


Fig 2 Example of upper trapezius SEMG data for a single operator in a single trial under two experimental conditions (Macintosh and Glidescope®).

The literature has thus far focused on measuring the forces applied to the patient's airway. Hastings and colleagues[7] demonstrated rapid decay of force applied with time, which was related to operator fatigue and decreased effort, thus suggesting that forces could be a potential limiting factor for difficult laryngoscopy. In a tongue oedema scenario, Savoldelli and colleagues[25] related a failed intubation by direct laryngoscopy to fatigue and overrunning of the allowed time or the number of attempts permitted.

Since videolaryngoscopes have been introduced, studies have shown significant reduction in forces applied compared with those of direct laryngoscopy, both in patients and manikins.[18 20] In particular, Carassiti and colleagues found reduction in force applied by the laryngoscope blade in Glidescope® laryngoscopy compared with Macintosh laryngoscopy, both in a manikin[17 19] and humans.[26]

We consistently found significantly reduced SEMG activation with Glidescope® compared with Macintosh. Statistical significance was not reached for all eight muscles, probably because of insufficient within-subjects comparisons, but ES, which quantifies the magnitude of the difference between two groups, was remarkable. Moreover, the pectoralis major, middle deltoid, triceps brachii, and biceps muscles, which were not statistically different between the two conditions, were also less activated with the Macintosh compared with Glidescope®. Instead, the upper trapezius, anterior deltoid, posterior deltoid, and brachioradialis were actively involved during Macintosh laryngoscopy but minimally recruited with Glidescope®.

An explanation of this finding could be that the extended vision of the Glidescope® allowed posture to be maintained, which engaged the upper limb muscles less and reduced SEMG activity. The comfort during manual handling tasks is

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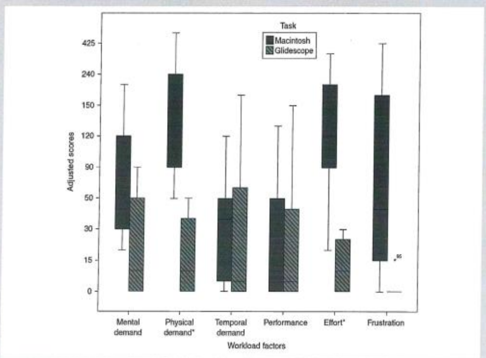


Fig 3 Box plot illustrating the distribution of the six workload factors under the two experimental conditions.

positively correlated with muscle EMG[27] and lower maximum muscular activity is correlated with higher levels of performance (efficacy, overall control, precision, and fluidity).[28]

Because generating the appropriate force constitutes a possible limiting factor, videolaryngoscopes could be useful to avoid errors due to a difficult laryngoscopy and differences in physical strength typically identified in novice females.[29] Nevertheless, the relationship between force and error during laryngoscopy has not been demonstrated and further studies are required.

Consistent with a decrease in the muscular activity, our results showed a significant reduction in perceived workload during Glidescope® laryngoscopy compared with Macintosh laryngoscopy, with particular respect to physical demand and effort.

Therefore, we suggest that muscular fatigue is a significant problem during direct laryngoscopy and that the introduction of more ergonomically efficient devices would decrease task-related workload.

Byrne and colleagues[13] validated a novel quantitative method to assess anaesthetist workload and emphasized that reducing workload in anaesthesia is a prominent issue for a safe clinical practice. As a confirmation, 64% of anaesthetists ascribe performance errors to excessive workload.[30]

Lessening workload in terms of physical demand and fatigue increases the availability of mental resources to plan and execute the operator's task and reduce the possibility of errors.[30] Assessing the perceived workload in many industries is a common method to test the usability of job instruments and thus maximize performance.[30 31] In anaesthesia practice, Weinger[14] considers that the potential clinical benefits of the use of airway management strategies may be partially offset by increased workload or a reduced ability to attend to unanticipated problems or new task demands.

Based on our results and the literature, a more ergonomic instrument, such as the Glidescope® videolaryngoscope, will reduce workload and potentially enhance clinical safety. A major limitation of the study was the use of the manikin, although it was intended to avoid inter-patient variability because it limits the generalizability of the results to clinical practice.

Application of our conclusions to other anaesthesia providers may also be limited because of different familiarity with the Glidescope® videolaryngoscope. To our knowledge, this is the first study that has provided a combination of objective and subjective measures related to both perception and action during the complex task of laryngoscopy. Our results emphasize the symmetric reduction in both a





subjective evaluation of physical demand and effort and the instrumental measurements of muscle activation.

## Conclusions

The reduction in task workload related to a lower upper limb muscular activity using the Glidescope® videolaryngoscope explained the operator's perception of less effort during laryngoscopy. The augmented vision of the Glidescope® and related postural adjustments were the key factors in reducing the amount of quantified SEMG activity and the perceived task load.

Further studies are required to verify the validity of this operator-centred model assessment and to determine whether the results obtained are applicable to patients, to a broad cross-section of anaesthetists, different intubation devices, and levels of training.

## Authors' contributions

D.C.: project development, study design, data collection, statistical support, and writing and reviewing the manuscript; F.M.: project development, study design, statistical support, and writing and reviewing the manuscript; A.S.: project development, ethical committee approval, study design, data collection, data analysis, and writing and reviewing the manuscript; S.F.: provided assessment and technical tools, methodological support, data collection, data analysis, and reviewed the manuscript; E.G.: study design, data analysis, and writing and reviewing the manuscript; P.C.: study design, statistical support, and review of the manuscript; E.F.O.: provided assessment tools, study design, data collection, data analysis, and writing and reviewing the manuscript.

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## Declaration of interest

None declared.

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