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Original Article

Clinical Experiences with the FRONT Formula for Pre-Operative Airway Assessment and Documentation: a Multi-Centre Study

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Abstract

Objective: The prediction of difficult airway is one of the most important challenges before general anaesthesia. This study aimed to assess the clinical usefulness of the FRONT score, a recently developed scoring system to predict and document airway difficulties.

Methods: This multi-centre, inter-observer, prospective and double-blinded study included 976 patients from two university centres. The pre-operative evaluation of the patients was performed by a pre-operative team of anaesthesiologists (team A) who evaluated and scored the expected difficulty of airway management. An intra-operative team of evaluators (team B) working independently of team A, performed the actual instrumentation of the airway and scored the actual findings. Both teams used the FRONT scoring system and worked independently of each other to ensure blinded assessments. The statistical analysis of the pre- and intra-operative FRONT scores was performed in an off-line blinded manner.

Results: Our results show a fair and promising association between pre-operative composite FRONT score and that observed at the induction phase (Spearman=0.43). Among the score components, the best correlation was observed for the F and R components (kappa=0.44 and 0.36, respectively), and the worse correlation was observed for the O and T components (kappa=0.25 and 0.24, respectively).

Conclusion: The FRONT formula for the prediction and documentation of the airway status is a simple and effective method for assessing and defining airway management difficulties. Further prospective studies are required to assess the sensitivity and specificity of the system.

Keywords: Difficult airway; prediction of intubation, documentation of airway status, FRONT score

Introduction

Difficult intubation remains a challenging problem during general anaesthesia in approximately 4.5%-7.5% of apparently normal patients (1, 2) and may lead to serious complications in certain cases (3).

The methodological approach to secure the upper airway comprises three basic steps: a) face mask ventilation for pre-oxygenation, b) laryngoscopy or insertion of the supraglottic device and c) tracheal intubation for securing and isolating the airway. These steps are influenced by several individual constitutional factors that may lead to difficulties during tracheal intubation for general anaesthesia. Therefore, many investigators have attempted to identify scoring systems that are easy to use and sufficiently sensitive for predicting a difficult airway during the pre-operative period. Among others, the Mallampati and modified Mallampati scores, measurements of the thyromental and sternomental distance, mouth opening test and Wilson risk score have frequently been suggested. In a recently published meta-analysis, Shiga et al. (2) reported a poor-to-moderate sensitivity for all these tests and indicated that a combination of thyromental distance and Mallampati score has the highest predictive value. A further limitation of these scores is that they do not specify in which of the above three phases the expected difficulties will be encountered or the morphological/functional location of the expected problem.

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The FRONT score is a formula recently developed by Biro (4), which has the potential to describe both, the location and he severity of the impending airway difficulty. The term FRONT is not an acronym alone its characters are derived from F for face, R for row of teeth, O for oral cavity, N for neck and T for trachea. In this study, we assessed the clinical usefulness of this scoring system in a regular clinical routine setting in an unselected patient population.

Methods

This multi-centre, inter-observer, prospective and double-blinded study included 976 patients from two university centres: 250 from the University of *(Institution's name removed)* and 726 from the University Hospital *(Institution's name removed)*. Patients from the surgical services provided by the two university centres [general surgery, abdominal surgery, vascular and cardiac surgery, neurosurgery, ear-nose-throat (ENT) and maxillofacial surgery] and who were scheduled for elective interventions under general anaesthesia were included. The study was conducted with informed agreement and written consent by all involved patients in accordance with the approval of the Ethics Committee no. 5184 issued on 04.28.2014 by the *(Institution's name removed for anonymisation)*. The study was registered on ClinicalTrials (Clinical Trails.gov identifiers: *removed for anonymisation*).

Every patient was evaluated by two separate teams of anaesthetists, team A (pre-operative evaluators) and team B (intra-operative evaluators). There was no communication between the two examinations to keep team B blinded to the assessment results of team A. Both teams comprised specialist and resident anaesthetists with at least 6 months of professional training and clinical experience. Team A performed the clinical airway evaluation during the usual pre-anaesthetic consultation, whereas team B performed or was directly involved in anaesthesia induction. Thus, team A made a pre-operative judgement on the potential airway difficulty using the FRONT scoring system, whereas team B described the clinical findings while inducing anaesthesia and securing the airway.

Team A used an evaluation form that included the individually obtained FRONT formula in which every capital letter corresponds to an anatomical region involved in managing the airway, namely F for 'face', R for 'row of teeth', O for 'oral cavity', N for 'neck' and T for 'trachea'. For each region, the anaesthesiologist had to assess any possible anatomical or functional findings that were considered to have an impact on the pending airway management. To deal with comparable results, a common scale for assessing the degree of difficulty was used by all team A members: 'F' involved every anomaly in the context of the face (lips, mouth, nose, chin, cheeks and beard), 'R' involved every anomaly in the context of teeth or edentulous gingiva (distance between incisors and reduction in temporomandibular joint movement), 'O' involved every anomaly in the context of the space between the teeth and the epiglottis (soft and hard palate, tonsils and tongue), 'N' involved every anomaly in the context of the neck (shape, curvature, length, diameter and cervical spine mobility) and 'T' involved every anomaly in the context of the trachea (pathological changes in the space between the epiglottis and carina, particularly obstructions).

To predict the expected difficulty level of any possible airway management, the subscript numerals 0, 1 or 2 were attached to the respective capital letters thus representing the severity level of morphological or pathological changes observed in the specific anatomical region. These levels corresponded to a degree of dysmorphism or loss of function.

These severity scores were:

- 0 (zero) if no difficulty was expected.
- 1 for moderate difficulty expected. Such a situation might require the use of alternative methods of airway management at the level of one of the three components of upper airway management (mask ventilation, laryngoscopy and intubation) and/or the possible involvement of an expert.
- 2 for high difficulty expected. This situation might encompass a high degree of difficulty or impossibility to be solved using conventional airway devices and therefore would require the use of alternative methods and/or the presence of an expert.

The specific degrees of severity allocated to the different locations used during a pre-operative consultation are summarised in Table 1.

If the clinical examination could not reveal data regarding a specific region, the capital letter was replaced by a lowercase letter. For example, in certain cases, the formula appeared as FroNT or FRONt (with no information about R and O in the first case, and no information about T in the second one). Thus, team A obtained predictions of airway difficulties that might occur during airway management by team B. After intubation, the involved team B member had to assess and document the found degree of difficulty, before disclosure of the findings reported by team A.

The criteria for describing intra-operative difficulties are summarised in Table 2.

The study was considered to be an inter-observer investigation because each patient was examined by two or more individuals. The main outcome parameter was the comparison of prediction scores produced by team A with the clinical results found by team B.

Statistical analysis

All data were recorded in MS Excel and were analysed using the Statistical Package version 11.0 for Windows (SPSS®, SPSS Inc., Chicago, IL, USA). For comparisons of the results obtained by team A with the factual findings by team B, a 3×3

Table 1. Criteria for pre-operative assessment and grading for all five FRONT levels

'F'	
0	Normal level of difficulty or no difficulty expected
1	Difficulty to apply air tight facial mask ventilation by one person (difficulty to maintain SpO_2 level of >92% with 100% O_2) or inability to prevent the decrease in SpO_2 level during facial mask ventilation.
2	Increased ventilation difficulty, requiring the presence of two anaesthetists to maintain the patient's oxygenation or inability to ventilate the patient with the facial mask.
'R'	
0	Normal level of difficulty or no difficulty expected
1	Incomplete teeth, loose teeth, edentulous status, incisor protrusion, prognathia, micrognathia, limited opening of the mouth but still >3 cm, expected difficulty with direct laryngoscopy and/or insertion of a supraglottic device.
2	Mobile teeth, mouth opening <3 cm, laryngoscopy or insertion of a supraglottic airway device impossible
'O'	
0	Normal level of difficulty or no difficulty expected
1	Laryngoscopy and intubation difficult expected by intra-oral mass, abscess, anatomical anomalies (large tongue)
2	Laryngoscopy and tracheal intubation expected to be extremely difficult or impossible
'N'	
0	Normal level of difficulty or no difficulty expected
1	Reduced mobility of the cervical spine, short neck, bulky chest, special positioning of the patient necessary (roll under the shoulders)
2	Immobile cervical spine
'T'	
0	Normal level of difficulty or no difficulty expected
1	Expected trouble for passing the tube through the glottis (polyp, tumour and abscess) and a tube with a smaller diameter is necessary
2	Severe obstruction in the upper airway (polyp, tumour, abscess and paralysis of the vocal cords), tracheal stenosis, tracheomalacia

SpO_2: pulse oxymetric saturation; O_2: oxygen

contingency table was constructed for the individual items of the FRONT score, and they were compared using kappa statistics. To assess the correlation between the pre- and post-operative composite FRONT scores, Spearman analysis was performed. Data are presented in a scatterplot with Spearman correlation analysis. The threshold for significance for all tests was set at α=0.05.

Results

A total of 976 consecutive patients, 483 males (mean ± SD 52.83±15.95 years) and 493 females (51.36±15.83 years), undergoing elective surgery were included. The distribution of surgical disciplines among the 976 investigated interventions comprised 481 abdominal, 20 vascular, 39 cardiac, 110 neuro-facial, 128 maxillo-facial and 135 ENT surgeries.

Among the total cohort, 624 patients (63.9%) were predicted to have a normal (zero) cumulative FRONT score during the pre-operative assessment. From the same group of 624 patients, 480 (76.9%) were found to have a zero cumulative FRONT score after induction of anesthesia. There were 352 patients with a positive prediction for a difficult airway (cumulative FRONT score > 0), of which 130 cases (36.9%) was found to have a cumulative score of zero (0). When considering the intra-operative findings, 612 (62.7%) patients had normal intubation conditions. Among these patients, only 31 (5.1%) were judged to have a cumulative FRONT score of >1 during the pre-operative assessment. In patients with an intra-operative cumulative FRONT score of >1 (n=364), pre-operative assessment revealed a score of 0 for 141 (38.7%) patients.

Regarding the association between the pre- and intra-operative values of the FRONT score, the pre-operative assessment of the different FRONT components showed the best inter-observer association for the F and R components, and the association for the N component could also be considered fair. The least positive correlation coefficient was observed for component O, followed by component T. According to the statistical analysis, p values showed a high inter-observer association (p<0.001 for all components). Data are summarised in Table 3.

Table 2. Criteria for intra-operative assessment and grading of all five FRONT levels

'F'	
0	Normal level of difficulty or no difficulty
1	Difficulty to seal the face mask accordingly by one person to maintain SpO_2 level of >92% by ventilating with oxygen.
2	Inability to maintain SpO_2 level of >92% by ventilating with oxygen and handling the face mask by two persons.
'R'	
0	Normal level of difficulty or no difficulty
1	Incomplete dentition, protruding incisives, prognathia, micrognathia, reduced interincisive gap <3 cm, thus explicitly hampering (but not completely preventing) intubation or supraglottic device insertion.
2	Incomplete dentition, protruding incisives, prognathia, micrognathia, reduced interincisive gap <3 cm, limiting intubation or supraglottic device insertion.
'O'	
0	Normal level of difficulty or no difficulty
1	Macroglossia, presence of tumours or other findings with increased oral tissue mass, tongue base processes, which hamper the performance of direct laryngoscopy (Cormack/Lehane grades up to 3°), conventional intubation or the insertion of a supraglottic airway. Final success could be achieved after two attempts to secure the airway with any adopted technique.
2	Macroglossia, presence of tumours or other findings with increased oral tissue mass, tongue base processes, which prevent the performance of direct laryngoscopy (Cormack/Lehane grade 4°), conventional intubation or the insertion of a supraglottic airway. Tracheal intubation could be achieved only after recurring to a visualising technique (e.g. flexible fiberoptic).
'N'	
0	Normal level of difficulty or no difficulty
1	Reduced cervical spine mobility, short neck, risk for spinal cord damage by certain head positions that hamper direct laryngoscopy and conventional means of tracheal intubation. Successful intubation possible by >2 attempts. Supraglottic airway insertion is not affected.
2	Reduced cervical spine mobility, short neck, risk for spinal cord damage by certain head positions that prevent direct laryngoscopy and conventional means of tracheal intubation. Tracheal intubation could be achieved only after recurring to a visualising technique (e.g. flexible fiberoptic). Supraglottic airway insertion may have been affected.
'T'	
0	Normal level of difficulty or no difficulty
1	Difficult forwarding of a tracheal tube with regular diameter to a mid-tracheal position. Supraglottic airway insertion is not affected.
2	Impossible forwarding of a tracheal tube even with a reduced diameter to a mid-tracheal position. Supraglottic airway insertion is not affected, but ventilation is difficult or impossible. Necessity to apply jet ventilation or bypass the oro-tracheal route by creating a trans-tracheal access.

SpO_2: pulse oxymetric saturation; cm: centimetres

Association between the pre- and post-operative composite FRONT scores (Figure 1): The highest inter-observer association was observed when a composite FRONT score was calculated and correlated (R=0.43, p<0.001).

Discussion

The prediction of a difficult airway remains a major concern in anaesthesia. The incidence of a difficult airway is high and accounts for 5% of all cases in the emergency departments (5). A general limitation in the real life clinical setting is that one cannot hold all kind of alternative airway equipment at any time in any location. Therefore, it is helpful to know in advance which type of airway problem is expected in each individual patient and consequently which logistic precautions have to be taken in advance. In this context, we consider that it is important to identify pre-operative difficulties that may arise, with the closest possible appreciation of location and severity.

Unfortunately, the classical methods of assessing difficult airway are not very predictive for conducting clinical airway management measures. Cattano et al. (6) showed that the predictive method for a possible difficult airway proposed by the American Society of Anesthesiologists (which is based on 11 distinct airway features) did not improve the outcome of airway-related efforts (7). Shiga et al. (2) compared the classical predictors of a difficult airway such as the Mallampati score and thyromental distance and found for each single test, a low sensitivity (20%-62%) and moderate specificity (82%-97%). The results of prediction improved only if the two individual tests were combined. In this study, the preoperatively assessed FRONT score showed a fair predictive value of

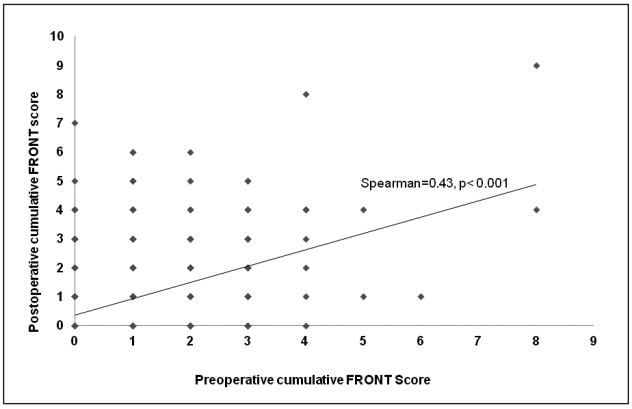

Figure 1. Linear correlation between pre-and intra-operative composite FRONT scores (Spearman=0.43, p<0.001)

76.9% for normal intubation conditions. Inversely, in cases where normal intubation situation was found during anesthesia induction, the pre-operative screening gave a correct prediction in 94.9% of the cases. This observation is consistent with the suggestion of Shiga et al. (2) who strongly emphasized the use of multifactorial combined scoring systems.

If a difficult airway is expected, one can prepare the anaesthesia according to locally suitable protocols, and the surprise of a sudden difficulty with an unpredictable outcome is alleviated. This is especially important if anaesthesia induction is performed by an individual different from the one who made the pre-anaesthetic evaluation. Therefore, it is essential that the communication between the person who has done the preoperative investigation and the person who performs anesthesia is precise enough in order to prevent misunderstandings and inadequate preparation of the case. Usually this type of communication occurs in written form, via a note in the patient's chart that has to be as complete as possible. However, text messages reflect the subjective opinion of the observer only, so that their accuracy and reliability is of limited value. Therefor it is essential to improve communication at this level, and the FRONT formula may improve the qualitative and quantitative content of airway-related data.

A simple global score for an expected airway difficulty is not sufficient because it does not contain any hint regarding the location and functional severity of that specific difficulty. It is important that the anaesthetist who performs the anaesthesia is well informed regarding all aspects of the potential difficulty and can at least approximately deduct from this message the best methodological approach to deal with the ensuing problem. Insufficient identification of the reported intubation difficulty can lead to an increased risk and a bad outcome (6). The herein investigated FRONT formula is not a completely new concept. Other airway assessment formulas such as the el-Ganzouri-Index or LEMO© have been introduced over two decades ago (8). While the el-Ganzouri-Index is very complex, LEMO© has been predominantly used in emergency cases (9). Only FRONT provides comprehensive data for the clinician who did not preoperatively evaluate the patient personally and who is relying on the judgement of somebody else. Here the combination of morphological, functional and gradual data coded in the formula is of great informative value. FRONT creates a fast, all-encompassing, intuitive image of the prevailing airway situation. In particular, FRONT is primarily intended for documentation of an already found airway difficulty in the sense of a "post hoc" assessment, and less as a predictor obtained during the preoperative assessment. We cannot exclude an additional predictive value, but this has to be proved in a separate setting on a much larger patient population. The morphological order of the components along the intubation pathway - from the exterior (F) to the interior (T) - is represented by the order of characters in the acronym, and therefore the anaesthetist might view the chronological order where and when difficulties may appear during the airway procedure, be it during facial mask ventilation, laryngoscopy or during advancement of the tracheal tube.

Our results showed a good correlation between pre-anaesthetic prediction and intra-anaesthetic findings of airway-related problems, thus indicating that the FRONT formula is a simple and effective method for assessing and defining airway difficulties. Certainly, more experience from prospective trials has to be collected about the predictive capacity of the FRONT formula, as well as about its suitability to be used as a simple and convenient mode of documentation of past airway-related difficulties.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Debrecen University.

Informed Consent: Written informed consent was obtained from her patient who participated in this study.

Peer-review: Externally peer-reviewed.

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