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Original article

Peak inspiratory flow as predictor for tracheotomy

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ABSTRACT

Objectives: Quantitative evaluation of upper airway obstruction cannot be commonly performed under acute dyspnea, especially in head and neck cancer (HNC); the decision whether or not to perform airway control surgery may be difficult to reach. Peak inspiratory flow (PIF) has been previously demonstrated to be a useful tool to decide on decannulation after HNC surgery. The aim of the present study was to assess the role of PIF as a standardized non-invasive tool in quantifying severe inspiratory dyspnea requiring emergency tracheostomy.
Materials and methods: A single-center prospective observational pilot study analyzed PIF measurements in 22 patients exhibiting acute dyspnea due to upper airway obstruction.
Main outcome measures: The decision whether or not to perform tracheotomy was taken prior to PIF measurement. PIF was measured with a hand-held PIF meter (In-Check method), and laryngeal fiberoscopy was then performed. Obstruction severity was defined by PIF values.
Results: PIF could be measured prior to tracheotomy (imminent in 21 cases, postponed in 1) in all cases. PIF values below 53.1 L/min (i.e., 18.3% of theoretic value) correlated with necessity for emergency tracheotomy. This threshold is concordant with that previously found for the feasibility of decannulation (60 L/min).
Conclusions: PIF is a non-invasive quantitative parameter assessing severity of upper airway obstruction, that may be helpful in decision-making for tracheostomy. Testing is simple, quick and reproducible.

1. Introduction

Upper airway obstruction in head and neck cancer (HNC) can occur before, during and after treatment. Obstructive tumor (larynx, hypopharynx) and bilateral laryngeal palsy or stenosis may cause severe dyspnea, and emergency tracheostomy may become mandatory. In addition, after treatment, laryngeal dyspnea may arise due to recurrent HNC or to post- radiotherapy edema. The severity and tolerance of inspiratory dyspnea may be difficult to assess for general practitioners, emergency physicians and radiotherapists. Laryngeal fiberoscopy performed by otolaryngologists sheds light on morphological features, but provides inadequate functional assessment of the laryngeal obstruction [1]. Until now, the decision to perform tracheostomy or controlled laryngeal intubation in case of respiratory distress has commonly been taken by the otolaryngologist on the basis of clinical criteria, severity of laryngeal dyspnea [2] and other criteria such as a context of recurrent HNC or comorbidity, notably cardiac and pulmonary.

Since the 1970s, several authors have used conventional spirometry to evaluate upper airway obstruction [3–5]. In these studies, the greatest changes were in inspiratory parameters of the flow-volume loops. More specifically, peak inspiratory flow (PIF), maximal inspiratory flow at mid-vital capacity (MIF 50) and forced inspiratory volume in the first second (FIV1) have been shown to correlate with extrathoracic airway obstruction [6]. Guerlain et al. [7] were the first to describe a portable hand-held inspiratory flow meter to evaluate upper airway obstruction, and also nasal obstruction [8]. It was thus demonstrated that PIF could be a safe and effective means of assessing the likely success of decannulation after HNC surgery [7]. It is a simple, inexpensive, non-invasive clinical tool, easy to use at the bedside and in the office. PIF $\geq$60 L/min, without cannula, appeared to be predictive of successful decannulation in these patients [7], lower PIF values requiring recannulation.

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Acute upper airway obstruction can occur in several clinical situations: in HNC but also in bilateral laryngeal palsy, laryngotracheal stenosis, laryngotracheal inflammation, or after traumatic injury. Whatever the etiology, acute upper airway obstruction needs to be promptly but carefully diagnosed, evaluated and managed. The appropriate decision is taken by the otolaryngologist, but emergency practitioners may be concerned in first line. Urgent tracheotomy under local anesthesia or controlled intubation for laryngeal laser debulking are the commonly available options to secure the airway [9–11].

PIF measurement can be used in acute inspiratory dyspnea, as a decision-making criterion for tracheostomy in all cases, whereas conventional spirometry with flow-volume loop is unsuited to acute conditions.

The aim of this observational study was to assess the usefulness of PIF, measured on a hand-held PIF meter (In-Check method), in quantifying severe upper airway obstruction requiring imminent airway control, and to compare previous reports of PIF used in decision-making for decannulation/recannulation after HNC surgery.

2. Patients and methods

This prospective observational study was performed between November 2011 and December 2015 in our Head Neck Surgery Department. Inclusion criteria comprised: adults with upper airway obstruction and severe dyspnea, in most cases for head and neck squamous cell carcinoma (HNSCC). Emergency tracheostomy or controlled tracheal intubation with tumor debulking was discussed. Exclusion criteria comprised: patients without PIF measurement before tracheostomy: no PIF measurement, or patient exhausted or unconscious due to severe dyspnea or necessitating an immediate salvage procedure.

Systematic upper airway fiberoscopy was performed for qualitative assessment of upper airway obstruction.

PIF was performed and recorded by the physiotherapist or by the otorhinolaryngologist before airway control, using a hand-held PIF meter by the method previously reported [7].

PIF was measured in sitting position. The PIF meter (In-check oral method, HS Clement Clark International Ltd, Haag Streit group) has a single-use mouthpiece and nose clip; the transparent body is designed to allow visual inspection before use. Results are graduated in L/min, with a margin of error of ±10% (i.e., 10 L/min) according to the manufacturer.

Once the procedure was well understood by the patient, the best value of at least three consecutive measures was taken [7,8]. Patients inhaled with maximum effort following slow complete exhalation.

Results were expressed per patient as PIF value (L/min) and percentage of theoretic PIF value (calculated from Bass's data) [12].

Decision to control the airway, and notably to perform tracheotomy, was taken by the otorhinolaryngologist after physical examination including laryngeal fiberoscopy, prior to PIF measurement.

Mean PIF value was calculated with standard deviation; median value, lower quartile, upper quartile and range were calculated and summarized in box plots. Data were analyzed using Microsoft Excel.

The PIF study [7] was approved by the *Commission d'évaluation et de recherche observationnelle en otorhinolaryngologie* (CEROL: review board of the Society of Otolaryngology, France). Data were strictly anonymous.

Table 1
Patient characteristics.

Mean age (n = 22)	59.6 years (38–79)
Gender (n = 22)	
Male	72.7% (n = 16)
Female	27.2% (n = 6)
Etiology (n = 22)	
Primary tumor or during chemotherapy	40.9% (n = 9)
Following HNC surgery[a]	9.0% (n = 2)
HNC recurrence after treatment or secondary HNC	40.9% (n = 9)
No HNC recurrence after treatment	4.5% (n = 1)
Bilateral laryngeal palsy	4.5% (n = 1)
Tracheostomy (n = 22) 100% (n = 22)	

[a] Following HNC surgery associated with regional HNC recurrence in one case.

3. Results

3.1. Participants

Twenty-two patients with laryngeal dyspnea were eligible for inclusion during the study period (Table 1): 16 male, 6 female; mean age, 59.6 years (range 38–79 years). All patients had HNSCC, except for 1 with bilateral laryngeal palsy. Onset of dyspnea was at initial laryngeal HNSCC diagnosis in 8 cases, during chemotherapy in 1 case, postoperatively following HNSCC surgery with no primary tracheostomy in 2 cases, including 1 with recurrent regional adenopathy, during follow-up after HNSCC treatment in 10 cases, including 9 with tumor relapse, or after laser cordotomy in 1 case (Table 1).

In recurrent or secondary HNSCC, the mean interval after complete primary treatment was 25.8 months (range 2–120 months).

3.2. Tracheostomy

Tracheostomy was performed in all patients (in emergency in 21 and at 10 days in 1), under local anesthesia in 20 cases and general anesthesia with intubation in 2.

The primary non-fenestrated cuffed cannula was usually replaced the day after surgery by a fenestrated cuffless tracheostomy tube with the same diameter.

3.3. Peak inspiratory flow results

In this series, mean PIF value before tracheostomy was 53.13 L/min (range, 35–100; *SD* = 14.5); median, lower quartile and upper quartile were respectively 50 L/min, 45 L/min and 60 L/min (Table 2) (Fig. 1). Mean percentage of theoretic PIF was 18.35% (range, 11.67-33.33%; *SD* = 4.3); median, lower quartile and upper quartile were respectively 18.33%, 16.07% and 19.86% (Fig. 2).

A PIF ≤ 53.13 L/min (18.35% of theoretic value) appeared to be predictive of severe upper airway obstruction requiring imminent tracheostomy, except in 1 case (patient 16) in which tracheostomy was postponed for 10 days as the patient preferred to undergo tracheotomy later, nearer home in another hospital.

One patient (case 13) exhibited a PIF value of 100 L/min, but dyspnea in this case was due both to recurrent HNSCC with upper airway obstruction (initially treated by supracricoid laryngectomy then radiotherapy) and to acute pneumonia from laryngeal aspiration.

86% of patients exhibited PIF ≤ 60 L/min prior to tracheostomy.

3.4. Post-tracheostomy period

Decannulation was performed after 3 months in the patient with bilateral laryngeal palsy (patient 18), and in 1 patient who was tracheotomized at day 2 after HNSCC surgery (patient 12). Tracheostomy was maintained for 7 patients with progressive, recurrent or secondary HNSCC (patients 2, 11, 13, 15, 19, 21, 22) and in 1 patient without evidence of recurrent HNSCC (patient 16). Total pharyngolaryngectomy was performed in 6 patients with definitive

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