Peak inspiratory flow as predictor for tracheotomy

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Peak inspiratory flow to predict tracheotomy in head and neck cancer: an outcome research

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ABSTRACT

Objectives: Quantitative evaluation of upper airway obstruction cannot be commonly performed in acute dyspnea, especially for head and neck cancer (HNC); decisions to control the airway, such as tracheostomy, may be difficult. Peak inspiratory flow (PIF) has been previously demonstrated as a useful tool to decide decannulation after HNC surgery. The aim of this work is to assess the role of the PIF as a standardized non-invasive tool in quantifying severe inspiratory dyspnea requiring emergency airway control.

Materials and methods: In this monocentric pilot prospective observational study, we analyzed PIF mesures in 22 patients exhibiting dyspnea due to upper airway obstruction.

Main outcome measures: Decision to control the airway had been taken prior to PIF measurements. PIF values, measured with a handheld PIF meter (In-Check method) were registered, beside laryngeal fiberoscopy. The severity of upper airway obstruction was defined by PIF values.

Results: PIF could be performed prior to the decision of tracheostomy (imminent in 21, delayed 10 days later in one) out a total of 22 patients (21 HNC and 1 laryngeal paralysis). PIF values below 53.1 L/min (i.e 18.3% of theoretical value) appear as values found to consider airway control in severe inspiratory dyspnea. This value is concordant with the one previously found for decision of decannulation following HNC surgery (60 L/min).

Conclusions: PIF is a non-invasive, quantitative parameter to evaluate the severity of upper airway obstruction, that may be helpful in the decision for timely tracheostomy. Testing can be performed easily, quickly and reproductively, and confirmed in larger population.

KEY WORDS:

Acute upper airway obstruction, inspiratory dyspnea, peak inspiratory flow (PIF), tracheostomy, head and neck cancer

INTRODUCTION

Upper airway obstruction in head and neck cancer (HNC) can occur before, during and after treatment. Obstructive tumors (larynx, hypopharynx), laryngeal bilateral paralysis or stenosis may cause severe dyspnea, and an emergency tracheostomy may become mandatory. In addition, after treatment, a laryngeal dyspnea may be due to recurrent HNC or post-radiotherapy edema. Quantification of inspiratory dyspnea and its tolerance may be difficult to assess by general practitioners, emergency physicians and radiotherapists. In addition, laryngeal fiberoscopy performed by otolaryngologists gives information about morphological features, but provides inadequate functional assessment of the laryngeal obstruction [1]. Until now, the decision for tracheostomy or controlled laryngeal intubation in HNC 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 the patient's performance status (cardiac and pulmonary).

Since the 70s up to now, several authors use conventional spirometry to evaluate upper airway obstruction [3–5]. In these works, the most important changes were observed in the inspiratory parameters of the flow-volume loops. More specifically Peak Inspiratory Flow, Maximal Inspiratory Flow at mid-vital capacity (MIF 50) and Forced Inspiratory Volume in the first second (FIV1) have been correlated with extrathoracic airway obstruction [6]. Guerlain et al.[7] were the first authors who proposed a portable handheld inpiratory flow meter to evaluate upper airway obstruction, but it has also been previously reported to measure nasal obstruction [8]. By this method, it has been demonstrated that peak inspiratory flow (PIF) may be used as a safe and effective tool before decannulation in patients after head and neck cancer (HNC) surgery [7]. It is a simple, inexpensive, non-invasive clinical tool, easy to use at the bedside and in the office. A PIF greater than or equal to 60 L/min, without

cannula, appeared to be predictive of successful decannulation in these patients [7], a lower PIF requiring recannulation.

Acute upper airway obstruction can occur in several clinical situations, in HNC but also in bilateral laryngeal paralysis, laryngotracheal stenosis, laryngotracheal inflammation, or after traumatic injury. Regardless of etiology, acute upper airway obstruction needs to be promptly but carefully diagnosed, evaluated and managed. The appropriate decision must be taken by otolaryngologists but emergency practitioners may firstly be concerned. Urgent tracheostomy under local anesthesia or controlled intubation for laryngeal laser debulking are the common available options to secure the airway [9, 10, 11].

PIF measurements can be used in acute inspiratory dyspnea, especially as criteria to guide practitioners in the tracheostomy decision making for each patient, while conventional spirometry with flow-volume loop is inappropriate in acute conditions.

The aim of this observational study is to assess the usefulness of PIF, using a handheld PIF meter (In-Check method), in quantifying severe upper airway obstruction requiring imminent airway control, and to compare with previous results of PIF in the decision of decannulation/recannulation after surgery for HNC.

PATIENTS AND METHODS

This prospective observational study was performed between November 2011 and December 2015 in our Head Neck Surgery Department. Inclusion criteria were adults who exhibited imminent upper airway obstruction and severe dyspnea, in most cases for Head Neck Squamous Cell Carcinoma (HNSCC). An emergency tracheostomy or controlled tracheal intubation with tumor debulking was discussed. Exclusion criteria were patients who had no PIF value performed before tracheostomy (no measurement of PIF, patients exhausted or

unconscious due to severe dyspnea or necessitating an immediate salvage procedure were excluded from the measures/study).

Upper airway fiberoscopy was performed in all patients to qualitatively assess upper airway obstruction.

PIF was performed and recorded by the physiotherapist or by the otolaryngologist before airway control, by the method previously reported [7], with a handheld PIF meter.

PIF was measured in the sitting position. The PIF values were recorded with an officially recognized handheld inspiratory peak flow meter (In-Check oral method, HS Clement Clark International Ltd, Haag Streit Group), with a single-use mouthpiece and a nose clip. The transparent body of the In-Check device is designed to allow visual inspection before use. Results are graduated in L/min, and the standard error of the device's measurements, according to the manufacturer, is +/- 10% (i. e. 10 L/min).

When the procedure was well understood by the patients with the practitioner, 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 at the case's patient level, by PIF value (L/min) and by the percentage of theoretical PIF value (calculated from data of Bass) [12].

Decision to control the airway, especially to perform tracheostomy, was taken by the otolaryngologist after physical examination including laryngeal fiberoscopy, prior to PIF measurements.

DIP mean value and standard deviations were measured. Median value, lower quartile, upper quartile and extreme values were calculated and summarized in box plots. Data were analyzed by using Microsoft Excel.

The study of PIF [7] was approved by the Commission d'Evaluation et de Recherche Observationnelle en OtoRhinoLaryngologie (CEROL: Ethics Committee of the Society of Otolaryngology, France). Data were strictly anonymous.

RESULTS

Participants

Twenty two patients with laryngeal dyspnea were eligible during this period (Table 1). Sixteen patients were male, six were female, and their mean age was 59.6 years with a range from 38 to 79. Patients had a HNSCC except one who had a bilateral laryngeal paralysis. Dyspnea was related to a HNSCC (laryngeal) tumor (8 cases), occurred during chemotherapy (1 case), during postoperative HNSCC surgery in which no tracheostomy was initially performed (2 patients, with recurrent regional node HNSCC in one), followed previously treated cancer (10 cases, including 9 tumor relapse), or after laser cordotomy (1 case) (Table 1).

In recurrent or secondary HNSCC, the mean delay after initial complete treatment was 25.8 months (range from 2 to 120 months).

Tracheostomy

Tracheostomy was performed in all patients (imminent in 21 and delayed 10 days later in one), in 20 awake patients with local anesthesia, and under general anesthesia following intubation in 2 patients.

Initially, patients wore a non fenestrated cuffed tube. The cannula was usually changed the day after surgery for a fenestrated cuffless tracheostomy tube with the same diameter.

Peak Inspiratory results (Table 2) (Fig. 1-2)

In this series, before decision of tracheostomy, the mean PIF value was 53.13 L/min (range from 35 to 100, sd = 14.5), median value, lower quartile and upper quartile were respectively

50L/min, 45L/min and 60L/min (Fig. 1). The mean percentage of theoretical PIF was 18.35% (range from 11.67 to 33.33%, sd = 4.3), median value, lower quartile and upper quartile were respectively 18.33%, 16.07% and 19.86% (Fig. 2).

A PIF less or equal than 53.13 L/min (18.35% of theoretical value) appeared to be predictive of severe upper airway obstruction requiring imminent tracheostomy in these patients, except in one case (patient 16), whose tracheostomy was delayed by 10 days; this patient has decided to later perform tracheostomy near its residence, in another hospital.

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

A total of 86% of patients exhibited a PIF $\leq$ 60L/min before performing tracheostomy.

Post tracheostomy period

Decannulation was performed after 3 months on the patient with bilateral laryngeal paralysis (patient 18), and on one patient who was tracheotomized at day 2 following HNSCC surgery (patient 12). Tracheostomy was maintained for 7 patients with persistent, 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 on 6 patients with definitive tracheostomy (patients 5, 8, 9, 14, 17 and 20). Six patients died from their HNSCC (patients 1, 3, 4, 6, 7 and 10).

DISCUSSION

There are no specific guidelines in the decision making of upper airway control for obstruction. Decision is based on clinical severity criteria of dyspnea (inspiratory bradypnea, intercostal and upper sternal inspiratory depression, with or without stridor) [2], [13], and useful parameters to consider such as previous HNC and medical comorbidities (cardiac or

pulmonary diseases). In fact, even severe upper airway obstruction can be well tolerated, but the exhaustion of the work of breathing can suddenly transform the tolerated dyspnea into a rapidly life-threatening condition. Tolerance of inspiratory dyspnea may vary, as breathing is frequently precarious in patients on whom surgery or radiotherapy for HNSCC has been previously performed.

Spirometric peak flow measurements represent relatively simple methods currently utilised in pneumology departments to evaluate lower airway obstruction with peak expiratory flow [14, 15]. Spirometric peak flow measurements are however not currently performed in surgical or emergency departments for inspiratory dyspnea.

Beside morphological and qualitative criteria for imminent airway control, PIF provides a specific quantitative criteria to predict severe upper airway obstruction, in concordance to physical examination. The level of PIF lower than about 55 L/min (i.e. 18% of theoretical value) expressed severe upper airway obstruction in this series of 22 patients.

This observational study demonstrates that PIF is a non-invasive tool to measure the upper airway obstruction and to evaluate the severity of inspiratory dyspnea, helping in the decision for timely tracheostomy. This is in accordance with the PIF levels previously reported for decision of decannulation [7] : the level to secure decannulation was found to be higher than 60L/min, a rate lower than 60L/min suggest recannulation of patients for dyspnea. As this threshold remains at a minimum level of functionnal breathing it must be re-evaluated and reconsidered for each patient, on the basis of the clinical examination and tolerance. When the PIF is close to this threshold, close watch and repeated clinical evaluations and PIF measurements must be performed. Tracheostomy was delayed by few days in patient 16, since relative tolerance of more acute dyspnea resulting from an already chronic moderate dyspnea allowed a planned tracheostomy near its residence, though the risk of respiratory decompensation. One patient required tracheostomy for dyspnea, although the PIF was higher

than the values obtained in the series; however, the context of associated acute pneumonia to recurrent HNSCC with laryngeal obstruction resulted in global respiratory function failure. Except of this patient, none of our patients presented any pulmonary or cardiac acute disease. The physical examination and the morbidity of each patient remain essential.

In our trial, the severity of obstruction for locally advanced tumors and various comorbidities of patients did not permit controlled laryngeal intubation for tumor debulking in the 7 laryngeal cancers. It is, however an option that may always be discussed before decision of tracheostomy.

Our clinical trial also has some limitations and is an observational serie. No control population and no comparative study were possible, since acute inspiratory dyspnea always requires rapid management, and is life-threatening. However, in the follow up of patients with chronic tolerated laryngeal obstruction (laryngeal stenosis, head and neck treated patients), the value of PIF is widely higher than 60 L/min (data not yet published); however, the data collected remain selective, since all patients with moderate dyspnea are also followed by other practioners than Otolaryngologists. In addition, only two studies provide reference values for the PIF according to gender and age: the study of Bass [12] with 130 subjects using conventional spirometry, and the study of Tsounis [8] with 131 subjects using the In-check method. Data of normative PIF, with conventional spirometry and with In-check method in a population without respiratory disease (gender, age, weight) would be to consider. The standard error of the device's measurements of +/- 10% (i. e. 10 L/min), must be to consider, although the best value of at least three consecutive measures was taken in this study, like in previous publications [7, 8]. Normative data of PIF that we have also collected (data not yet published) remain higher than 150 L/min, but comparison with patients exhibiting acute upper airway obstruction remains difficult due to various results depending of gender, age and weight.

Currently, no other quantitative and reproducible thus objective scale for dyspnea is available in the context of emergency; the severity of obstruction is very subjective at laryngeal fiberoscopy, and some patients with severe upper airway obstruction may be paucisymptomatic in a steady state, but a slight imbalance can lead to severe decompensation which may quickly become life-threatening.

Scales of dyspnea, like the Dyspnea Index [16] and quality of respiratory life in respiratory diseases have been validated for upper airway obstruction [17, 18], but they are inadequate in emergency situations as can be conventional spirometry, therefore there where not performed in this case serie. No ABGs (arterial blood gases) have been performed before nor after control of the airway, because saturation and capnia often remain normal in case of even acute and severe laryngeal dyspnea; in this condition, hypoxemia and/or hypercarnia occur lately and abruptly.

PIF is an objective and reproducible tool to identify patients at risk of upper airway obstruction and to establish a management plan, beside physical examination. PIF measurements can monitor the response to medical treatment in acute dyspnea (nebulisations, corticotherapy). PIF could be also available in emergency unit, in unplanned clinical presentations (laryngeal traumatic injury, neck cellulitis). Furthermore, it could also be a useful tool to decide the cadence of follow-up in chronic laryngeal disease (inflammatory laryngeal disease, laryngeal stenosis, bilateral laryngeal paralysis disease, after treatment of HNC). The learning curve is fast, and it is cost-effective.

Repeated mesures of PIF, from the diagnosis of HNC, during follow up and when acute dyspnea occur, in a multicentric study, could provide a large amount of data that would refine the use of PIF. An objective and reproductible scale would allow a better understanding and management of the evolution of upper respiratoy obstruction at each step of the treatment of HNC for all practitionners, and especially younger ones.

It is also important to notice that measurements of PIF need full cooperation of the tested subject to validate the results [8]. Furthermore, even if the In-check method is easy to use and the learning curve is fast, a minimal practitioner´s experience is needed to confirm the validity of the values obtained.

CONCLUSION

PIF may help to evaluate acute upper airway obstruction and to optimize decision of imminent airway control, such as by tracheostomy in emergency and life-threatening situations. It may represent a specific tool in addition to clinical criteria and laryngeal fiberoscopy for routine clinic use. It is a simple, inexpensive, cost-effective, non-invasive, supplementary clinical tool that is easy to use at the bedside and in the emergency departments. The usefullness of the PIF in acute upper airway obstruction could be evaluated in a larger population.

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Conflicts of interest : none

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Table 1. Patient characteristics

Table 2. PIF values

PIF values expressed with minimal (min) and maximal (max) values. *dyspnea due to recurrent HNC associated with pneumonia due to aspiration, 7 months following surgery then chemoradiotherapy, ** the only patient in whom tracheostomy was delayed by10 days, ***dyspnea day one after laser cordotomy for bilateral laryngeal paralysis

% theoretical PIF values calculated on basis of age and gender PIF values from (Bass 1973) [12].

The standard error of the device's measurements, according to the manufacturer, is +/- 10% (i. e. 10 L/min).

Figure 1: Box plot representing median PIF value (50L/min) and lower and upper quartile (respectively 45L/min and 60L/min). Lower extreme was 35L/min and upper extreme was 100L/min.

Figure 2: Box plot representing median percentage of theoretical PIF (18.35%) and lower and upper quartile (respectively 16.07% and 19.86%). Lower extreme was 11.67% and upper extreme was 33.33%.

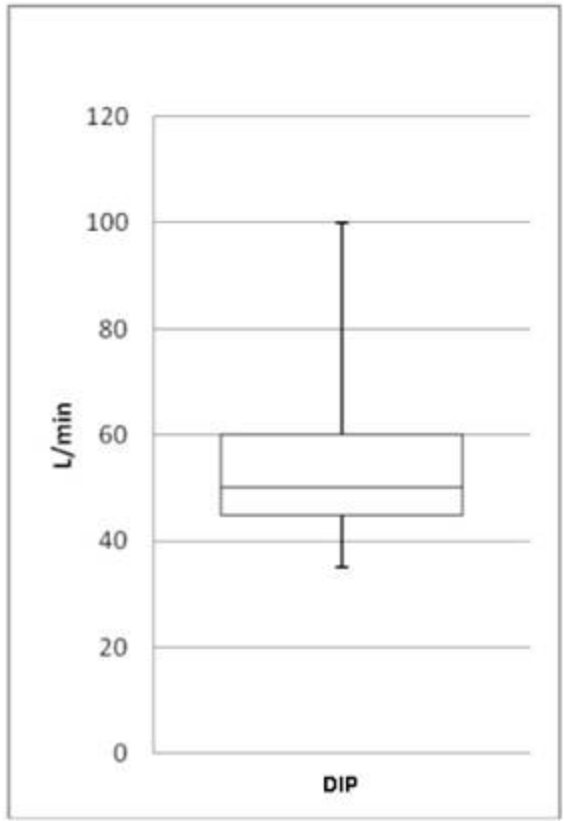
Table 1. Patient characteristics

Mean age (n=22)	59.6 years (38-79)
Sex (n=22)	
Male	72.7% (n=16)
Female	27.2% (n=6)
Etiology (n=22)	
Dyspnea in untreated or during chemotherapy	40.9% (n=9)
Post-operative HNC surgery*	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 paralysis	4.5% (n=1)
Tracheostomy (n= 22)	100% (n=22)

***: Post-operative HNC surgery associated with regional HNC recurrence in one**

Table 2. PIF values

Patients	PIF	% theoretical PIF value
1	55	18.33
2	55	18.33
3	65	20.44
4	50	16.67
5	60	20
6	75	23.56
7	55	17.3
8	35	11.67
9	60	18.87
10	45	17.86
11	45	19.23
12	40	13.33
13*	100	33.33
14	40	13.33
15	40	15.87
16**	50	21,37
17	60	20
18***	35	14.96
19	60	18.87
20	50	16.67
21	45	14.15
22	50	19.44
Mean	*53.13*	*20.45*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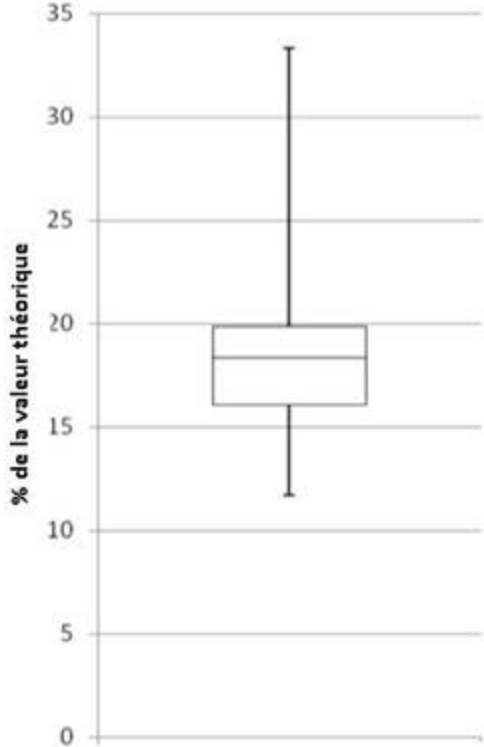
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