International Journal of Obstetric Anesthesia (2014) 23, 35–39
0959-289X/$ - see front matter 
http://dx.doi.org/10.1016/j.ijoa.2013.08.008

ORIGINAL ARTICLE

ELSEVIER
www.obstetanesthesia.com

# Pregnancy is associated with a decrease in pharyngeal but not tracheal or laryngeal cross-sectional area: a pilot study using the acoustic reflection method

N. Leboulanger,[a] N. Louvet,[b] A. Rigouzzo,[b] M. de Mesmay,[b] B. Louis,[e] M. Farrugia,[b] L. Girault,[b] A. Ramirez,[c] I. Constant,[b] J.-M. Jouannic,[d] B. Fauroux[c]
[a] *Department of Head and Neck Surgery,* [b] *Department of Anesthesiology,* [c] *Department of Pulmonology,* [d] *Department of Obstetrics and Gynecology, Armand-Trousseau Hospital, Université Paris,* [e] *INSERM, Unité U955, and CNRS, ERL 7240, Paris, France*

**ABSTRACT**

**Background:** The risk of difficult upper airway access is increased during pregnancy, especially in labor. Changes in upper airway calibre have been poorly studied during pregnancy. The acoustic reflection method is a non-invasive technique that allows a longitudinal assessment of the cross-sectional area of the upper airway from the mouth to carina. We used this technique to evaluate upper airway calibre during normal pregnancy.

**Methods:** We conducted a prospective, single centre, observational study with a clinical and upper airway acoustic reflection method evaluation of healthy women during the first, second and third trimesters of pregnancy, and up to two days and one month after delivery.

**Results:** Fifty women participated to the study. The mean pharyngeal cross-sectional area decreased between the first and third trimesters ($P < 0.001$) with no significant change of the minimal and mean tracheal cross-sectional areas. The Mallampati score increased during pregnancy between the first and third trimesters ($P < 0.001$).

**Conclusion:** Using measurements with the acoustic reflection method, normal pregnancy is associated with a significant reduction in the cross-sectional area of the pharynx and a concomitant increase in the Mallampati score. No change was observed in the minimal and mean tracheal cross-sectional areas.


***Keywords***: Pregnancy; Acoustic reflection method; Pharynx; Larynx; Trachea

## Introduction

Pregnancy, labor and delivery are associated with an increased risk of difficult airway management and failed intubation.[1–7] Generalized weight gain and upper airway edema are known to be associated with intubation difficulties. Although the physiological modifications of the respiratory system during pregnancy are well known,[8] changes in upper airway calibre are less well documented. This may be due to the limited range of non-invasive investigations that can be used in pregnant women. Standard X-rays may be inaccurate, computerized tomography (CT) scanning involves substantial radiation exposure and magnetic resonance imaging (MRI) is costly and uncomfortable for the patient. Furthermore, ultrasonography does not explore the intrathoracic airway, and endoscopy is invasive and its images may be distorted by the use of the fiberscope.[9] Clinical examination and assessment of the Mallampati score, which increases during normal pregnancy, remain the standard methods of examination.[10–12]

The acoustic reflection method (ARM) is a non-invasive, rapid and simple method to measure the longitudinal evolution of cross-sectional area. Since its first description by Fredberg et al. in 1980,[13] ARM has been used to explore snoring patients (acoustic pharyngometry), nasal compliance (acoustic rhinometry), obstruction of tracheal tubes by mucus plugging, misplacement of tracheal tubes and normal and pathological upper airways in children (larynx and trachea).[14–20]

To our knowledge only one study has used the ARM to analyze the pharynx of pregnant women during labor

Accepted August 2013
Correspondence to: Dr. N. Leboulanger, Department of Head and Neck Surgery, Armand-Trousseau Children's Hospital, 26 Avenue du Dr Arnold Netter, 75012 Paris – Université Paris VI, INSERM, Unité U955, 94010 Créteil, Paris, France.
*E-mail address:* nicolas.leboulanger@nck.aphp.fr

and delivery.[21] The authors observed a reduction in oral pharyngeal volume during the delivery with a concomitant increase in Mallampati score. The aim of our study was to analyse the evolution of the cross-sectional area of the upper airway by means of the ARM during normal pregnancy and to correlate the results with the Mallampati score.

## Methods

The study was registered in the clinical trials database (http://clinicaltrials.gov, NCT01087047), and was approved by our institutional review board (CPP Ile-de-France V). All the women gave written, informed consent. Consecutive pregnant women at the Armand Trousseau Maternity Hospital, without concurrent medical condition or obesity (body mass index $<25\ kg/m^2$), aged 18 years or more and with a normal singleton pregnancy at their first routine ultrasound scan (before 12 weeks of amenorrhea) were invited to participate in the study. Women with underlying disease that could interfere with the results of the recordings, such as pre-existing airway problems, pregnancy complications, multiple pregnancy, and/or preterm labor were not included or secondarily excluded.

Upper airway ARM recordings were performed during the first (T1), second (T2), and third (T3) trimesters of pregnancy, and within two days postpartum (PP) and one month after delivery (LR, last recording). At each ARM recording, a basic physical examination including weight, blood pressure, neck circumference, and Mallampati score, was performed. Height was measured at T1 only.

The equipment used in this study, its calibration and results using in vitro models, has been described previously.[22–24] Briefly, the acoustic reflection device consists of a Plexiglas tube (20 cm long, 1.4 cm diameter) connected to a horn driver, on which two microphones (piezoresistive pressure transducers, 8510-B; Endevco France, Le Pré Saint-Gervais, France) are inserted. The Plexiglas tube is connected via a mouthpiece and filter to the patient (Fig. 1). An acoustic wave (0.01–6 kHz) is generated by the horn driver through the Plexiglas tube, which is driven by a computer via a digital-to-analogue converter (Benson Hood Laboratories, Pembroke, MA, USA). Microphone outputs are fed into an analogue-to-digital converter and recorded. ARM allows assessment of both geometric and mechanical properties of the respiratory system.[24]

For a standard ARM measurement, the patient breathes through the mouth for approximately four seconds. During this period, the ARM device generates 10 consecutive acoustic waves. The use of a nose clip is not recommended because it may generate artefacts due to the relaxation of the soft palate, causing a double upward (in the nasopharynx) and downward (in the pharynx and beyond) echo of the airwave.[15] For the same reason, ARM is not suitable for exploring the airway beyond the carina and in patients with a non-operated cleft palate or tracheostomy. ARM allows a complete longitudinal analysis of the whole upper airway, from the pharynx to the carina. The geometric properties give a spatial representation of the proximal airway: the cross-sectional area of the airway as a function of the distance along the longitudinal axis with a spatial step increment $\Delta L$ of approximately equal to 0.4 cm. Results are given in numeric and graphic form (Fig. 2). Identification of the anatomical landmarks on the tracings is made by the clinician. Clinical examination and ARM measurements were performed during the same visit, by one of the senior practitioners (NL).

For the purpose of the present study, attention was focused on the pharyngeal and tracheal mean cross-sectional values (MPA, mean pharyngeal cross-sectional area; MTA, mean tracheal cross-sectional area), and on

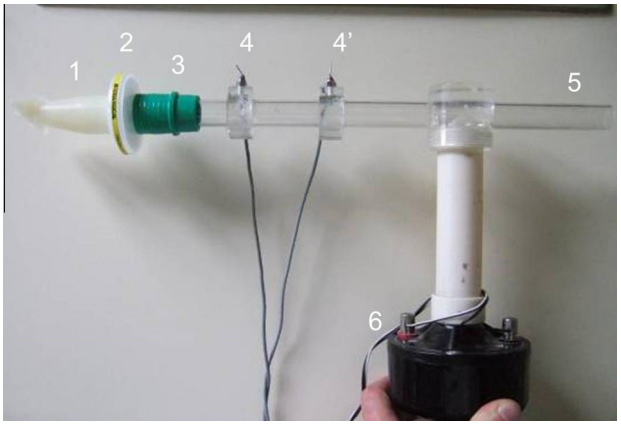


**Fig. 1** Acoustic device. 1: mouthpiece; 2: surgical filter; 3: adapter; 4 and 4': microphones; 5: open air tube side 6: horn driver.

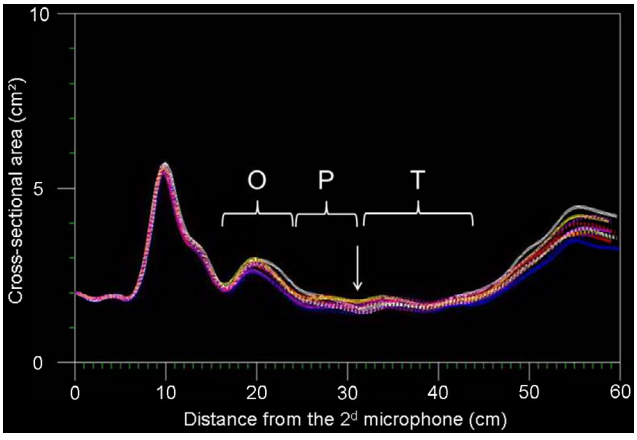


**Fig. 2** Normal ARM recording. O: oral cavity, P: pharynx, T: larynx and trachea; arrow; zone of minimum cross-sectional area (subglottic region).