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Relation between the collision force between vocal folds and the other parameters in phonating excised human larynges

A. Lagier^{1,2}, T. Legou³, P. Champsaur¹, A. Giovanni^{3,4} and F. Silva⁵

Introduction

The phonotraumatism is a complex mechanism. Collision force between the vocal folds is only one component of it [1]. Information about its relation with other aerodynamic, acoustic and electroglottographic parameters is still lacking.



Fig. 1: Pre-phonation configuration

Material and methods

- One healthy female larynx harvested from fresh cadaver (86 years old) according to the french ethical law.
 - Adduction in a stable phonation position using inter-arytenoid stitch and bilateral symmetric Montgomery[®] thyroplasty implants (see Fig. 1)
 - Larynx on experimental testbench (Fig. 2) without any tension applied to vocal folds
- Linearly varying subglottal pressure (P_{SG} in the range 0-20 kPa) while recording the external pressure (P_{ext}), the electroglottographic signal (EGG) and collision force (P_{cf}).

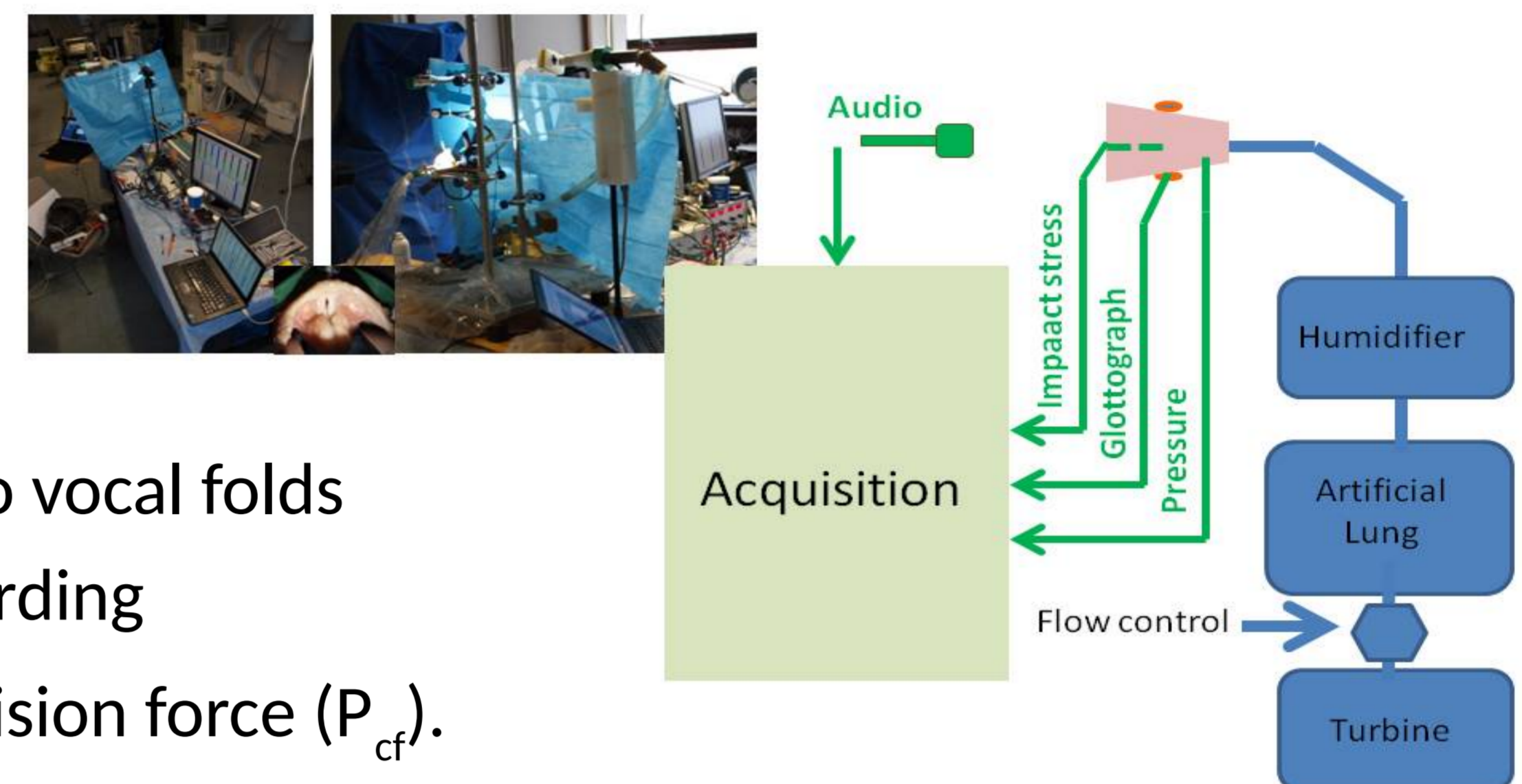


Fig. 2: Experimental testbench for human excised larynx

Fundamental frequency is extracted from the EGG signal

Results

Fig. 3 shows almost-linear variations of the acoustical signals (P_{ext} , f_0) with respect to the subglottal pressure. EGG and P_{cf} exhibit a saturation effect for high pressure values.

Fig. 4 evidences the nonlinear relation between the amplitude of collision force and the other parameters, except for the fundamental frequency which shows no correlation with P_{cf} .

On the contrary, the amplitude of the EGG signal is strongly correlated to f_0 as visible in Fig. 5

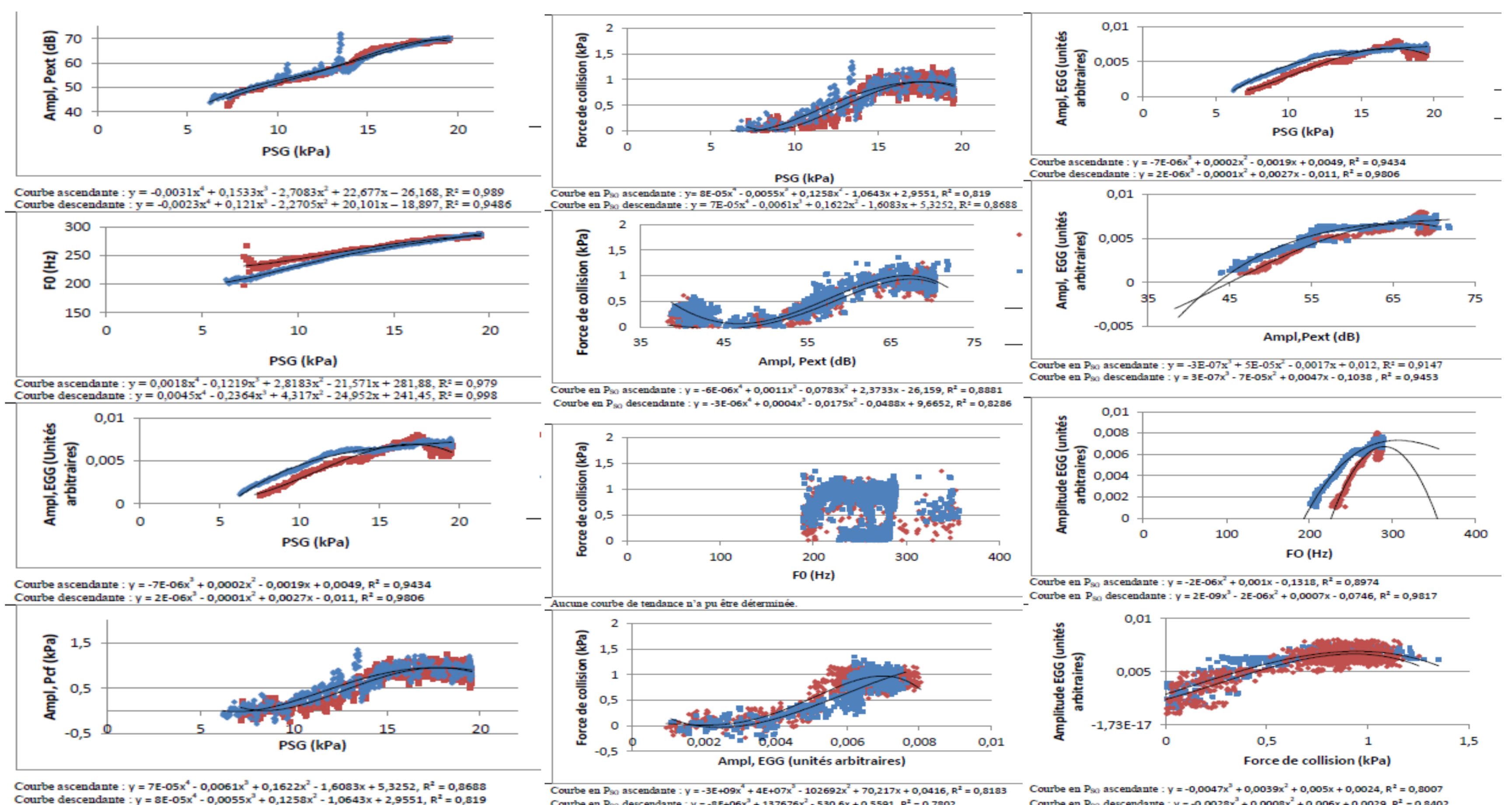


Fig. 3: Variations of the different parameters with P_{SG}

Fig. 4: Variations of the collision force w.r.t the other parameters

Fig. 5: Variations of the amplitude of EGG w.r.t the other parameters

Discussion

First, results on the impact of P_{SG} on classical voice parameters (P_{ext} , f_0 , EGG) are consistent with previous knowledge [2]. Then variations of the collision force correlate with the amplitudes of the external pressure and of the EGG signal (quantifying the glottal contact area [3]) with a slight hysteresis between increasing and decreasing P_{SG} .

For this experiment, neither muscular activation nor tension was applied to the folds so that only the aerodynamic control of f_0 was enabled. There seems to be no stiffening (increasing f_0) or softening (decreasing f_0) effect due to large amplitude vibrations as measured by the collision force.

The vocal folds collision force and the amplitude of EGG signal appear as two complementary descriptors to consider in order to understand the phonotraumatism. They both reflect the closed phase of the glottal cycle, which is supposed to be crucial for the phonotraumatism.

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