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Modeling clinical situations at risk of perineal tear during delivery

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Introduction

- Perineum :
 - Soft structure made of skin and muscles
 - Lowest part of the pelvic outlet
 - Guarantee of its integrity by analyzing its mechanical properties
- During delivery :
 - Induction of very large deformations of the perineum
 - Occurrence of more or less severe perineal tears
- Third- and fourth-degree perineal tears :
 - Synonymous : obstetrical anal sphincter injuries (OASIS)
 - Damage of the anal sphincter complex and / or the anal epithelium
 - Disabling disorders : anal incontinence, chronic perineal pain, sexual disorders
- Limited biomechanical data regarding the perineal behavior of women during delivery
- **Aim of our global project** : to model the clinical situations at risk of perineal tear during delivery to understand their mechanisms according to 3 main axes

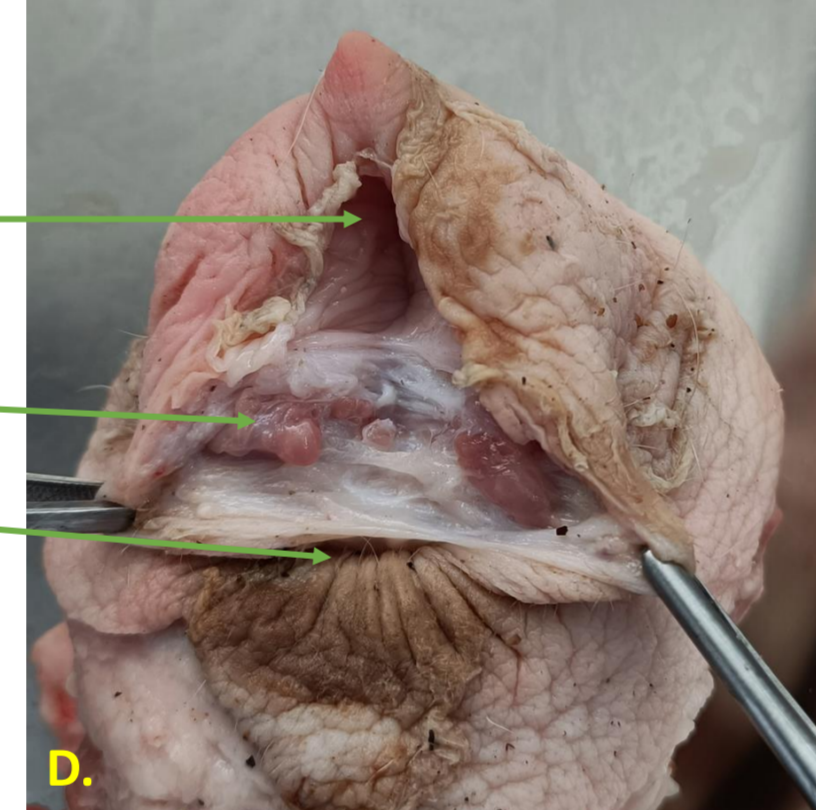
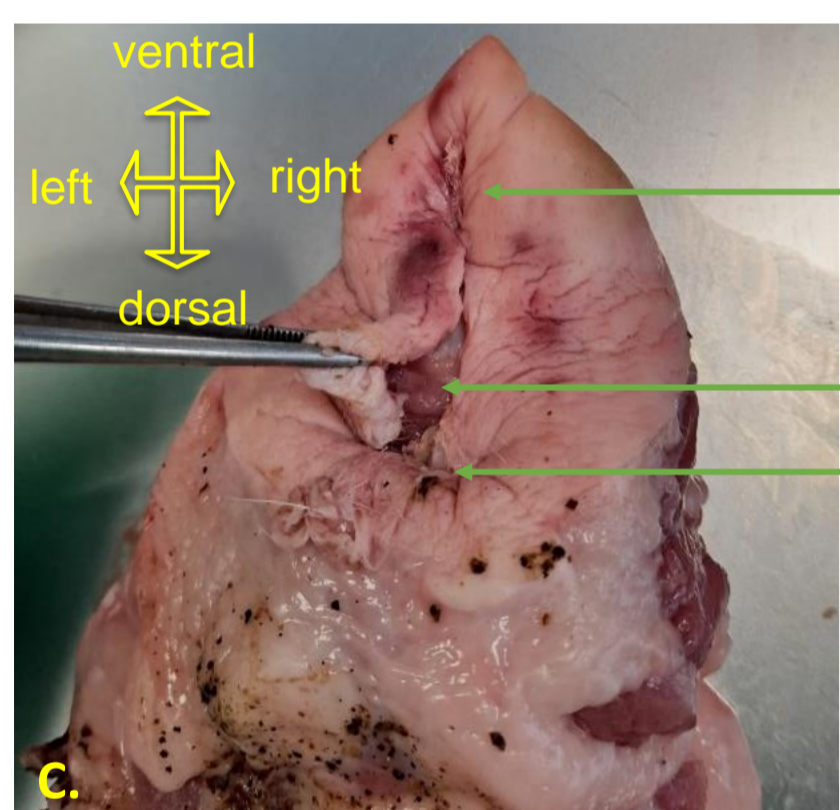
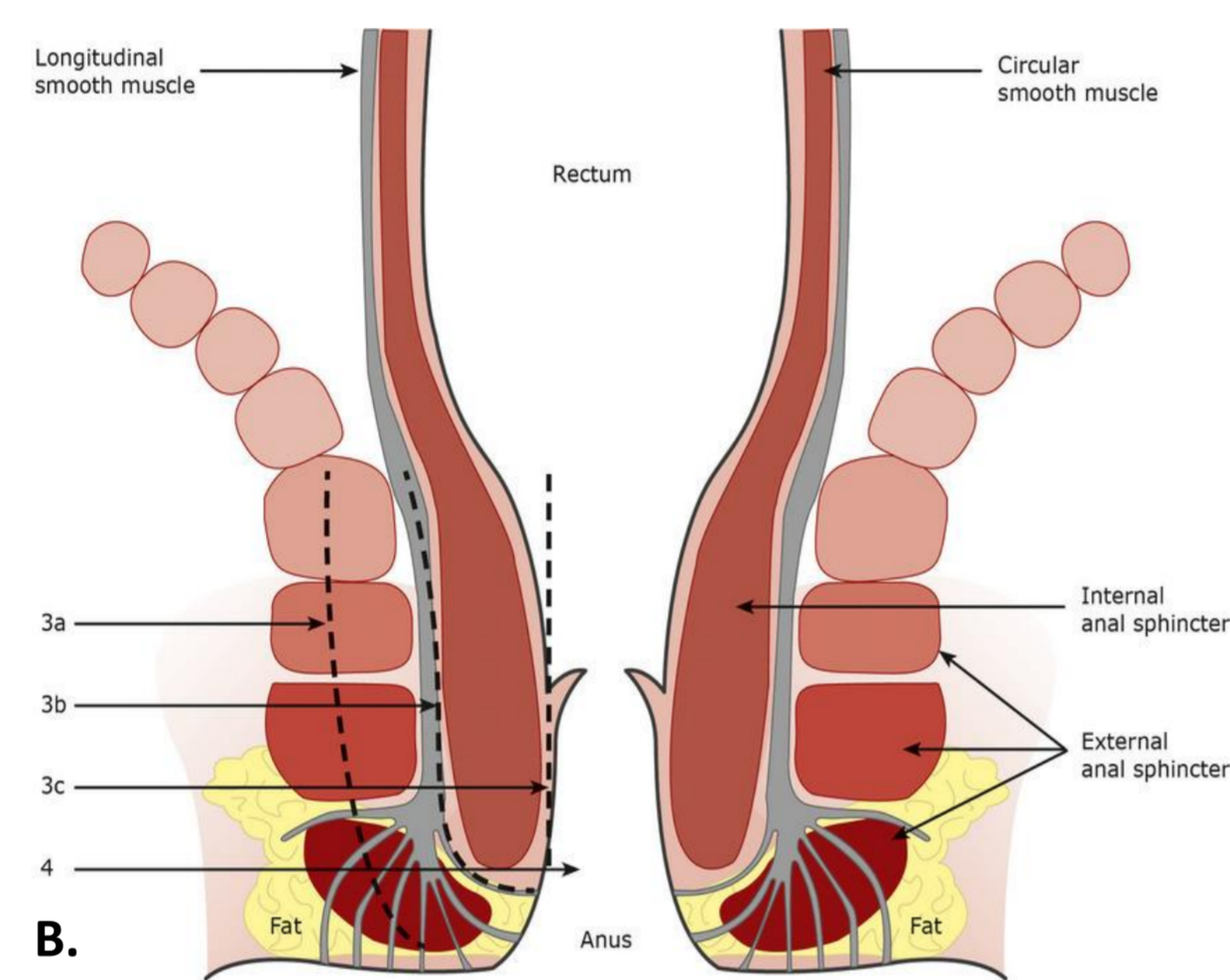
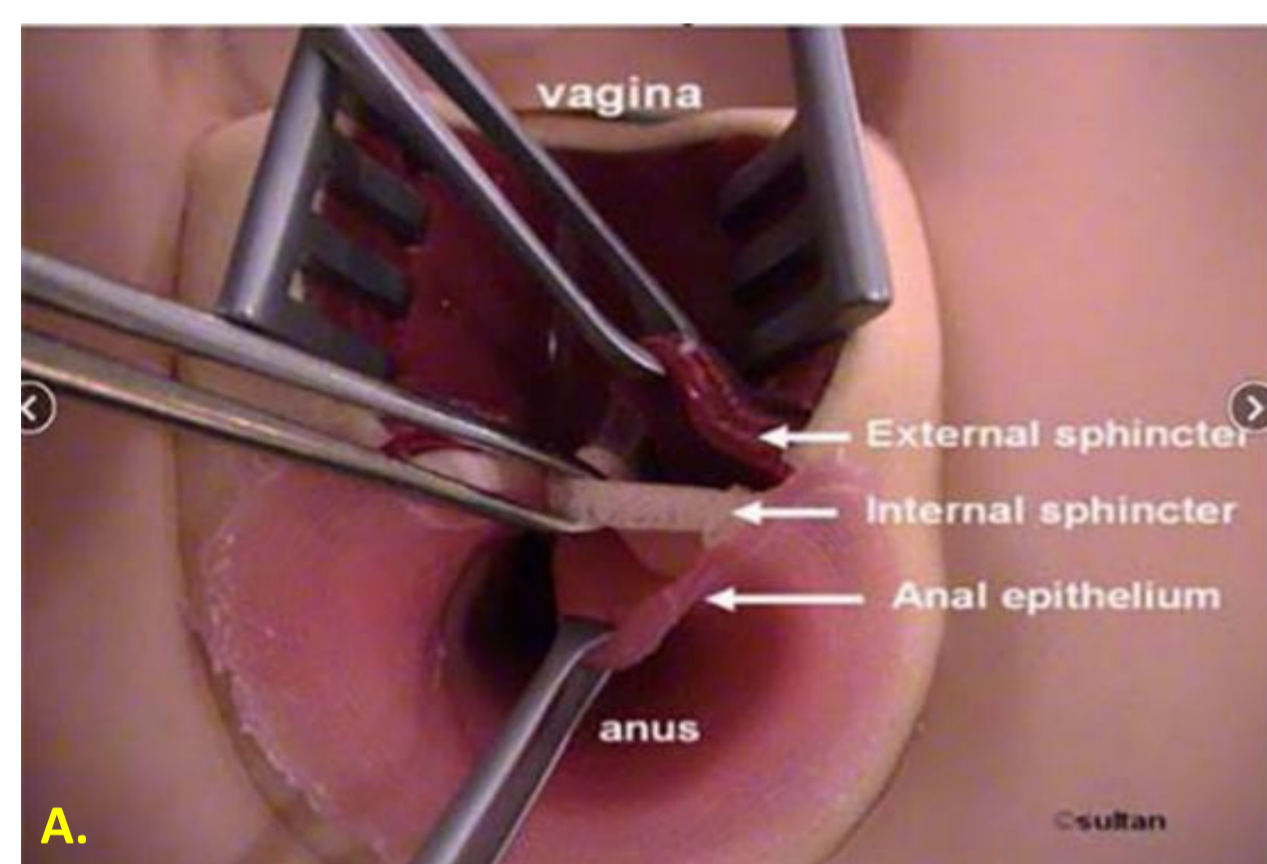


Figure 1. Anatomy of the perineum
A. Multi-layered perineum (*Sultan anal sphincter trainer*) B. Description of the anal sphincter (*Lone F, The Obstetrician & Gynaecologist 2012*) C. Sow's perineum D. Simulation of a stage III obstetrical anal sphincter injuries on a sow's perineum

First axis: mechanical properties of the soft tissues of the sow's perineum

Rationale for the sow model:



-Pros

- Easily accessible model
- OASIS suture training model
- Inability to perform in vivo tension tests

-Cons

- Absence of sow's perineal tear at delivery (no dystocia)
- Greater stiffness of the sow's perineum compared to humans

Exp: ultrasound, shear wave elastography, unidirectional tension tests, stereophotogrammetry

4 steps:

1. Study the influence of all experimental conditions on these tissues before determining the biomechanical properties

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2. Determine the biomechanical properties :
 - Hyperelastic behavior
 - Viscoelastic behavior
 - Fracture analyses
3. Simulation of the head expulsion using the Epino[®] device on the sow's perineum
4. Simulation of head and shoulder expulsion using the Epino[®] device on the sow's perineum

Second axis: clinical prospective study

Objective: to evaluate the perineal elasticity and mechanical fields (strain and stress) induced by the fetus during delivery.

Material & Methods:

- Prospective, longitudinal, monocentric study in the maternity hospital of Besançon
- Research study involving the human person (RIPH) of category 3 according to the Jardé law: request of the committee of persons protection in progress
- Inclusion criteria: Primiparous women over 18 years old with a singleton pregnancy of normal course
- Study design : an appointment at the end of the 9th month of pregnancy and an evaluation in the birth room at delivery (Figures 2. and 3.)
- Primary endpoint: to define a fracture criterium based on the threshold value of the equivalent strain obtained by stereovision camera

9 th month appointment	In the delivery room, during early labor (<5cm)	At delivery, before the beginning and during expulsive efforts	In the delivery room, after childbirth
<ul style="list-style-type: none"> • Demographic data • 3rd trimester fetal ultrasound data • Clinical data 	<ul style="list-style-type: none"> • Clinical data • Obstetrical ultrasound data • Perineal elastographic data • Perineal deformation data (stereophotogrammetry) 	<ul style="list-style-type: none"> • Obstetrical ultrasound data • Perineal elastographic data • Perineal deformation data (stereophotogrammetry) 	<ul style="list-style-type: none"> • Obstetrical data • Neonatal data • Perineal elastographic data • Neonatal measurements (head and shoulders)
<ul style="list-style-type: none"> • Dynamic pelvic MRI data if performed during pregnancy 	<ul style="list-style-type: none"> • Perineal elastographic data • Perineal deformation data (stereophotogrammetry) 		

Figure 2. Precision on the study design



Figure 3. Acquisition of elastographic (*Gachon et al. BMC Musculoskelet Disord, 2020*) measurements at the 9th month of pregnancy and during delivery

Third axis: numerical model

- Incorporation of mechanical, imaging and clinical data into a digital model obtained from dynamic pelvic MRI of the perineum and pelvic system
- Development of a numerical model predicting the mechanical response of the perineal tissues, the fissure front and its path during the deformations due to fetal progression