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

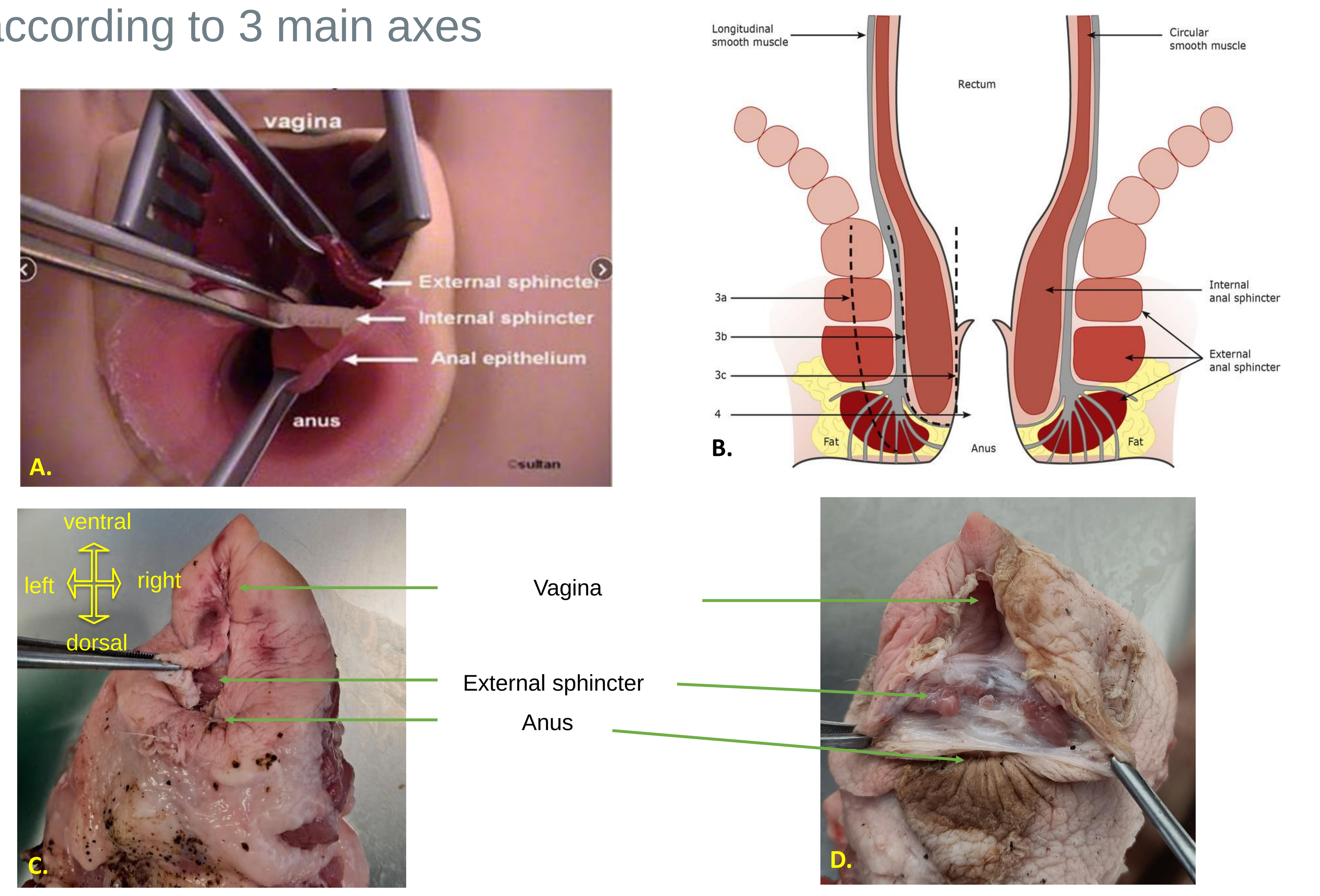

Figure 1. Anatomy of the perineum
A. Multi-layered perineum *(Sultan anal sphincter trainer)* **B.** Description of the anal sphincter *(Lone F, The Obstetrician & Gynaecologist 2012)* **C.** Sow's perineum **D.** Simulation of a stage III obstetrical anal sphincter injuries on a sow's perineum

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

Rationale for the sow model:

-Pros	-Cons
-- Easily accessible model	-- Absence of sow's perineal tear at delivery (no dystocia)
-- OASIS suture training model	-- Greater stiffness of the sow's perineum compared to humans
-- Inability to perform in vivo tension tests	

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

4 steps:

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

9th 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
• Demographic data • 3rd trimester fetal ultrasound data • Clinical data • Dynamic pelvic MRI data if performed during pregnancy • **Perineal elastographic data** • **Perineal deformation data (stereophotogrammetry)**	• Clinical data • Obstetrical ultrasound data • **Perineal elastographic data** • **Perineal deformation data (stereophotogrammetry)**	• Obstetrical ultrasound data • **Perineal elastographic data** • **Perineal deformation data (stereophotogrammetry)**	• Obstetrical data • Neonatal data • **Perineal elastographic data** • **Neonatal measurements (head and shoulders)**

Figure 2. Precision on the study design

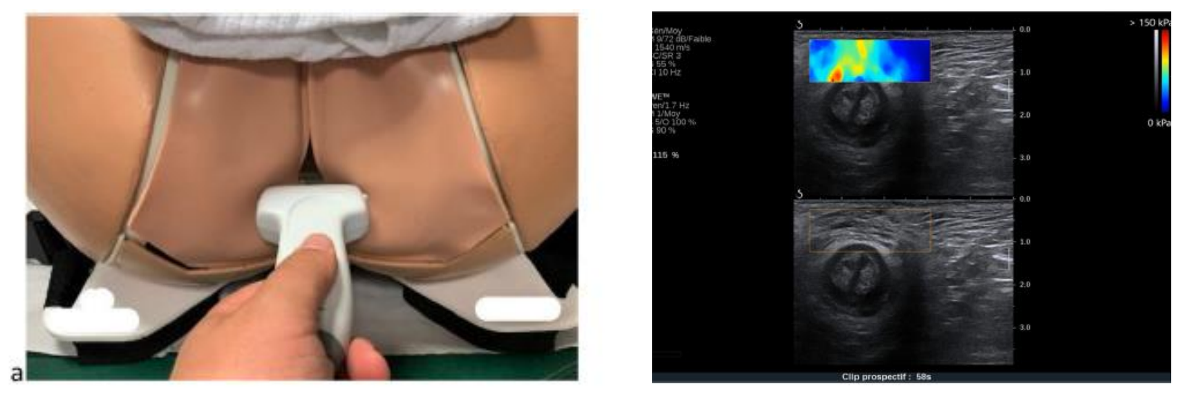

Figure 3. Acquisition of elastographic *(Gachon et al. BMC Musculoskelet Disord, 2020)* measurements at the 9th month of pregnancy and during delivery

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

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