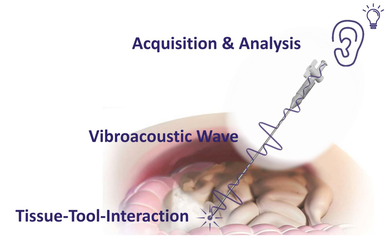
The sound of insertion – an audio based guidance technology to improve laparoscopic entry with Veress needle

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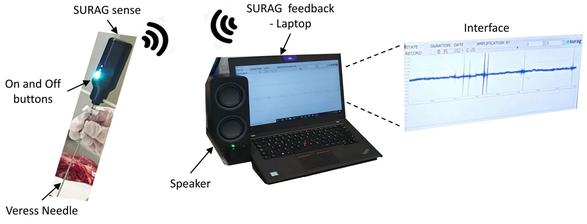
Objective

- **Surgical audio guidance (SURAG)** is a novel sensing technology for obtaining complementary information from surgical instruments that has shown high potential for the guiding of percutaneous needle insertions.
- **Vibroacoustic (VA) waves** resulting from any interactions between the needle tip and the tissue naturally propagate through the needle shaft.
  - VA waves can be acquired and detected using a sensing configuration located at the proximal end of the instrument.
  - VA signals can be processed to extract meaningful guidance information that can be further translated into interpretable feedback to surgeons.
  - Events such as needle tissue-tissue passage and punctures of layers can be automatically identified, magnified and translated to visual and acoustic feedback.



The main objective of this work is to evaluate if Veress needle punctures events can be automatically magnified and identified during insertion.

Description of technology



- With a plug-and-play feature, SURAG sense can be easily attached to every Veress needle.
- It acquires vibrations originating from needle-tissue-interactions during the procedure.
- The acquired data is wirelessly sent to SURAG feedback, which processes it in real-time to magnify punctures and convert them to the audible range.
- The acoustic information can be interpreted and used by the surgeon to improve needle placement and to avoid complications.

Phantom and animal experiments

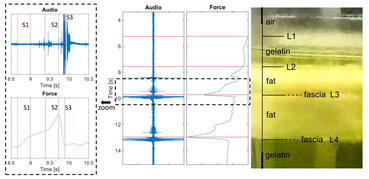


Phantom experiments
- Ex-vivo porcine tissue and synthetic tissue phantoms
- Automatic insertions at a controlled velocity and manual insertions
- Dataset of >2000 Veress needle insertions in phantom

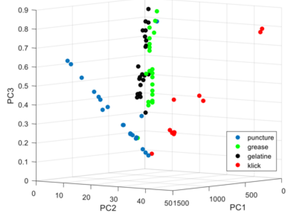
Animal experiments
- 10 non-living pigs (30-70 Kg)
- 210 insertion recordings
- Cavity events time instants manually annotated from video recordings of the experiments

Preliminary results

Phantom Veress needle insertions results

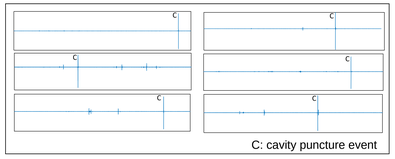


- Every needle tip-tissue interaction event appears clearly as abrupt changes in the VA signal. The signal is composed of several stages during puncture.
  - S1: needle inner-outer core interaction
  - S2: tissue puncture
  - S3: obturator retraction
- Features can be extracted, which can cluster events occurring during Veress needle insertion.



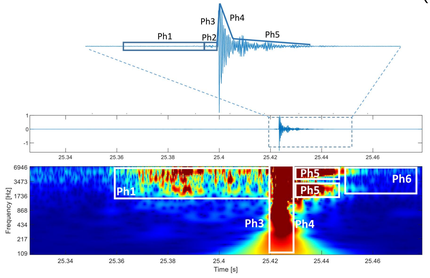
Animal Veress needle insertion results

Cavity event signal excitation during needle insertion

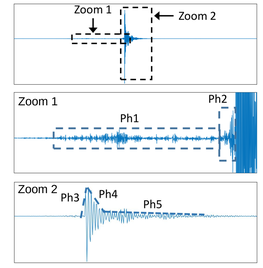


100% of the annotated cavity puncture events in non-living pigs produced clear and detectable excitations in the VA signal.

Time-frequency (TF) characterization of a cavity puncture event



Time-domain (TD) characterization of a cavity puncture event



From TD and TF representations 6 phases (PH) characterize a cavity puncture.
- Ph1: needle inner-outer core friction
- Ph2: tissue puncture
- Ph3,4,5: attack, decline, release
- Ph6: post-puncture

Presence or absence of these phases, and features computed from them allows the full identification of a puncture

Conclusions

- The SURAG technology has demonstrated its potential as an easy-to-use device for guiding laparoscopic entry with Veress needle.
- Due to its add-on characteristic utilizing the Luer-lock, it can be connected to any Veress needle in the market to provide real-time feedback information to the user.
- As a result, no change of workflow or any active components in direct contact with patient's tissue and organs are required.

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