Author’s response to reviews

Title: A novel approach to neuraxial anesthesia: application of an automated ultrasound spinal landmark identification

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Author’s response to reviews:

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To: Dr Guangde Tu
The Editor
BMC Anesthesiology

Dear Dr Tu,

RE: “A novel approach to neuraxial anesthesia: application of an automated ultrasound spinal landmark identification” (Submission ID: BANE-D-18-00450)
Thank you very much for the review of our manuscript entitled "A Novel Approach Using an Automated Ultrasound Spinal Landmark Identification for Neuraxial Anesthesia" (Submission ID: BANE-D-18-00450). Based on reviewer 4’s suggestion, we have changed the title to “A novel approach to neuraxial anesthesia: application of an automated ultrasound spinal landmark identification”.

We appreciate your comments and kind help to improve on the manuscript.

Please find below point-by-point responses to each of the comments (in Italic red font). Amendments to the text are tracked-change in the revised manuscript.

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Vincent Chan (Reviewer 1): This prospective study examined the usefulness of a new automated ultrasound spinal landmark identification for lumbar spinal anesthesia in 100 surgical patients who required spinal anesthesia. This Gabor-based automatic ultrasound spinal level identification system was reported in Conf Proc IEEE Eng Med Biol Soc. 2017:3146-3149. According to the inventors, "spine level identification is initiated by detecting the location of the sacrum using a classifier based on a support vector machine. Image stitching is then conducted to produce a panorama image of the spinal area. During this process, the location of spinal processes are enhanced using a Gabor filter and detected through template matching. The locations of the spinal processes are tracked and used as an overlay on the ultrasound image in real-time. The system then informs the anesthetists when the correct spinal level has been reached."

To me as a lay person, I don't understand how this intelligent image processing system works and how it identifies ultrasound spinal landmarks e.g., spinous processes, interspinous spaces (in particular the L3/4 interspinous space), the sacrum, the transverse processes, the laminae and the anterior and posterior dural complexes. Does this system still require clinician input to designate the spinal levels? Please explain.

------ Thank you very much for your time and effort to review our manuscript.
The system does not require clinician input to designate the spinal levels. We have provided additional pictures in Methods (Figure 1A and 1B) to explain the automated ultrasound spinal landmark identification process step by step. Now the paragraph has been revised to the following:

“The patient assumed a seated position with the lower back exposed. Ultrasound gel was applied to the lower back before the investigator placed an ultrasound curved array probe around the sacral region. The graphical interface of the software, integrated with the ultrasound machine, guided the investigator to first identify the sacrum as a hyperdense line which was reflected as a computer marked red line as shown in Figure 1A at the sacral region. [20] The investigator then moved the ultrasound probe in a steady vertical upward longitudinal direction of the lumbar spine and identified the spinous process that were reflected as triangular peaks. Subsequently the interspinous processes were identified and marked as rectangular white box (Figure 1A). Upon identification of the L3/4 interspinous space (Figure 1B), the system marked with a horizontal line along the midline of the probe by a surgical skin marker (Figure 1B, Figure 2). After the longitudinal section of the scan was completed, the investigator turned the probe 90 degrees clockwise around the probe centred to the transverse view. The transverse scan consisted of horizontal movements of the ultrasound probe along the previously marked line at the level of L3/4 by the investigator with minimal rotational movements to obtain the best view. The software would signal when the correct identification of the ligamentum flavum was visualized. (Figure 3) This position was then marked with a vertical line at the midline of the probe using a surgical skin marker.”

The details about how our image processing system works and how it identifies ultrasound spinal landmarks can also be found in our previous publication (full text) listed below (the reference number 13-20 in the revised manuscript).


Figure 1 is designed as the midline view of the lumbar spine. In fact, the bigger sonogram (upper panel) is most likely showing the laminae and not the spinous processes since they are quite deep. One would expect the spinous processes to be quite superficial (< 2 cm from skin) in most non obese subjects. The sonogram in the lower panel seems to show the L5-S1 interlaminar space. Again I am not convinced the sonograms show spinous processes and interspinous spaces.
Figure 2 is a transverse view showing the interspinous space. The hyper echoic line seems to be the anterior dural complex but it is unusually wide. I cannot tell where the posterior complex and the ligamentum flavum are.

To help the readers better understand, please describe your automated ultrasound spinal landmark identification process step by step using photos, images and sonograms.

------- The objective of this manuscript is to report the clinical application of the automated ultrasound spinal landmark identification system. The description of automated ultrasound spinal landmark identification process step by step can be found in our previous publications (reference 16-23).

We have also added additional pictures in Methods (Figure 1A and 1B) to explain the automated ultrasound spinal landmark identification process step by step in Methods. The previous Figure 1 and Figure 2 has been changed to Figure 2 and Figure 3, respectively.

The primary hypothesis of the study is that automated spinal landmark identification algorithm using image processing system would achieve a mean 90% first attempt success rate of spinal anesthesia. In my opinion, your study primary hypothesis should be a correlation between spinal landmark identification by the automated machine and identification by an expert anesthesiologist skilled in spine imaging. The key to a successful spinal needle insertion is multifactorial and not just related to proper identification of the interspinous space. Operator error e.g., wrong needle advancement angle can lead to failure too.

------- We agree with you that the key to a successful spinal needle insertion is multifactorial. However, as we stated in the Background, page 5, “Lumbar neuraxial procedures are typically performed via a ‘blind’ surface landmark and palpation guidance, …… The identification of this space demands good knowledge of the anatomy and some skills due to its complexity. The failure in palpation from patient factors such as obesity, abnormal spine or previous spinal surgery results in difficult needle placement, leading to higher rate of complications”. “Even in normal surgical patients, the neuraxial anesthesia needle insertion first attempt success rate is only about 50 to 60% when the palpation technique is used”
In addition, this system is also designed to train novice learners and used in patients with difficult spinal anatomy.

Therefore, the primary objective of our study is to investigate the first attempt success rate of spinal anesthesia.

Rakhee K. Goyal (Reviewer 2): It is a good study. However, I have not understood how the software was integrated with the ultrasound machine and how was it validated.

------ Thank you for your time and effort to review our manuscript. The software was integrated with ultrasound machine by connecting the video out port with a computer. We have done a validation study and the results has been published in Ultrasound Med Biol 2014, 40(9):1980–1990 and 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). 2016. (references 13 and 19).


Berrin Günaydin (Reviewer 3): This is a very well designed and well-written paper. However, I kindly suggest authors to shorten the introduction part since it is too long. My suggestion is either to omit the whole 1st page or to use the 1st page content in the discussion part accordingly if possible.

------ Thank you very much for your time and effort to review our manuscript.

We have revised the introduction and discussion accordingly.
Additionally, I kindly suggest authors to rename table 1 as 'demographics and success rates of the technique'.

------ The title of table 1 has been changed to “Demographic and clinical characteristics based on the success rates of the epidural insertion”

Adam Jacob (Reviewer 4): In the research article "A Novel Approach using an Automated Ultrasound Spinal Landmark…", the authors describe a single-center, prospective, cohort study of 100 women undergoing spinal anesthesia in which the needle insertion point was determined using an ultrasound-integrated, automated algorithm. Authors had previously developed this new technology, and validated its ability to correctly identify the L3-4 interspace. The present study represents the first clinical application of using the technology to identify the needle insertion site which would result in a successful 1st pass dural puncture. The first pass success of dural puncture was then compared to rates established in the literature. Authors reported a 92% success rate of dural puncture on the first needle pass when using the new technology to locate the needle insertion point, concluding that "… this novel automated ultrasound guided techniques would be useful to clinician to utilize ultrasound-guided neuraxial techniques with confidence to identify the anatomical landmarks on the ultrasound scans."

------ Thank you very much for your time and effort to review our manuscript.

I applaud the investigators for developing an ultrasound-integrated technology that can further aid clinicians for placement of neuraxial blocks. The technology was developed in the way that even a novel ultrasound user could follow the systematic approach to identify the L3-4 interspace. It's very promising… well done. As the authors correctly point out, there are some limitations of their findings and the generalizability. In general, is the automated algorithm you developed specific only to one type of ultrasound machine/manufacturer, or can it be used on multiple systems? You mention that you plan to investigate its use in complex and obese patients. Is the algorithm similarly accurate in detecting L3-4 in obese patients?

------ Thank you very much for your compliments.
The automated algorithm we developed is not specific to one type of ultrasound machine/manufacturer and it is able to connect to any video output port of ultrasound machines. Specifically, the laptop is connected to the ultrasound machine through a video capture card, such that all the anatomical information scanned from the ultrasound probe is transmitted to the laptop for image processing. The developed software can be implemented in the computer with different operating systems, i.e., Windows, Mac OS, Linux, etc. Notably, the software is compatible to all most commercially available ultrasound machines.

Yes, we are currently doing a clinical trial specifically on obese patients. The algorithm is refined in order to detect L3-4 in obese patients accurately.

Specific Criticisms/Questions:

1. Though generally well written, there are several grammar and syntax errors that could benefit from editorial review for English language.

------- Thank you. We have revised the manuscript accordingly.

2. The Introduction, though complete, is too long. Please condense this section by 50%. You should be able to summarize the background and knowledge gap in one page of text.

------- The introduction has been shortened. We have moved part of Introduction to Discussion.

3. The title needs some rewording. By leading with "A Novel Approach..." the reader is left wondering what exactly the novel approach is being used for. A novel approach to neuraxial anesthesia: application of an automated ultrasound... might better describe what the study is about.

------- Thank you for your suggestion, The title has been changed to “A novel approach to neuraxial anesthesia: application of an automated ultrasound spinal landmark identification”.

4. Abstract, Background - Please consider condensing this section, and moving your primary aim up to the Background.

------ Revision done.

5. Abstract, Methods - Please move the primary aim to the Background, and include more detail about what you actually did during the study.

------ The primary aim has been moved to the Background and more details of Methods have been added.

6. Abstract, Conclusions - I might suggest that "would" in line 58-59 be changed to "could" to soften your position a little. Not all clinicians may find this useful.

------ Revision done.

7. Background, lines 26-27 - Please be very clear about what you mean by "success," here and throughout the paper. In this case, I think you mean success in achieving dural puncture on the first needle pass. It's important to distinguish this, because there are several other factors that may influence the success of the actual spinal anesthetic (e.g., inadequate block height). You can successfully get a dural puncture on the first needle pass, but fail to get a successful spinal anesthetic because you gave the wrong dose of drug or forgot the lay the patient down after spinal injection and all the medication pooled in the sacral area.

------ Thank you for your suggestion. We have revised the statement as following: “the neuraxial anesthesia needle insertion first attempt success rate (success in achieving dural puncture on the first needle pass) is only about 50 to 60% when the palpation technique is used”.
8. Methods, page 9, lines 5-6 - Was ultrasound used to guide the needle also, or just identify the needle insertion point? Again, success of first pass dural puncture is dependent on correct needle trajectory as much as it is correct insertion point. What size needle was used?

------- The ultrasound was used to identify needle insertion point only. The needle was a 27G pencil point needle with a 20G introducer.