



RESEARCH

INFORMATION

A New Image Processing Method for Ultrasound Imaging to Diagnose Prostate Tumours



AIMS

Prostate cancer is the most common cancer in men but there is still no reliable way to identify cases. PSA levels and MRI imaging currently lead to a large number of unnecessary biopsies while also still missing significant cancers. Super resolution ultrasound imaging is a new and evolving application of contrast enhanced ultrasound imaging where images of blood vessel networks, including tiny blood vessels can be created. The aims of this work was to assess if super resolution ultrasound imaging could be feasible in imaging prostate cancer by: (in brackets the outputs as determined in the application):

- collecting ultrasound video data from patients with confirmed prostate cancer, who have elected to have surgery to remove the prostate.
- Generating algorithms for creating super resolution images from the data from prostate patients (Unit 1).
- Determining a clinical imaging protocol for collecting suitable ultrasound video data (Unit 2 Output 1).
- Estimating the ability of the processed clinical data in order to produce information on the vascular structure and blood flow dynamics of the prostate (Unit 2 Output 2).
- Understanding the accuracy of super-resolution maps in diagnosing prostate cancer (Unit 2 Output 3).



KEY FINDINGS

Currently there is no test for screening for prostate cancer (eg. equivalent to mammography for breast cancer) because of the lack of clear cost-effectiveness of any existing method. Here we demonstrated feasibility of a new technology that may provide a far more cost-effective imaging method.

- Super resolution ultrasound images of the prostate can provide information on the vascular networks within the prostate
- Confirmed locations of prostate cancer by comparison with pathology were associated with regions of higher volume and denser blood flow patterns.
- Other prostate structures and conditions, confirmed by pathology, could also be identified by vascular structures seen on super resolution images.
- The accuracy of super-resolution maps to diagnose prostate cancer has significant potential to be as good as or better than MRI.
- In the sample size it was shown that it is feasible to provide comparable diagnostic sensitivity to the current standard of care (MRI).
- All the above show significant potential to improve diagnostic specificity which stems from understanding all the different image features.



WHAT DID THE STUDY INVOLVE?

Patients who had already been diagnosed with prostate cancer and who had elected to have surgery to remove their prostate were the target cohort for the study. Data was collected from consenting patients just before they underwent surgery. The consent forms were provided at least two weeks in advance, in order for the patients to have adequate time to consider their participation to the research study.

Transrectal ultrasound imaging of the prostate was undertaken along with an IV infusion of ultrasound contrast agent. Videos of the ultrasound data were saved. At a later time the ultrasound video was processed with algorithms developed to create super resolution images. When available the pathology reports and images were collected and used to identify the actual confirmed regions of cancer in each prostate. Vascular patterns within the prostate associated with different prostate structures and conditions could also be identified using comparison with information provided by pathology. Over 40 individual prostate locations have been assessed by ultrasound imaging with comparison to pathology.

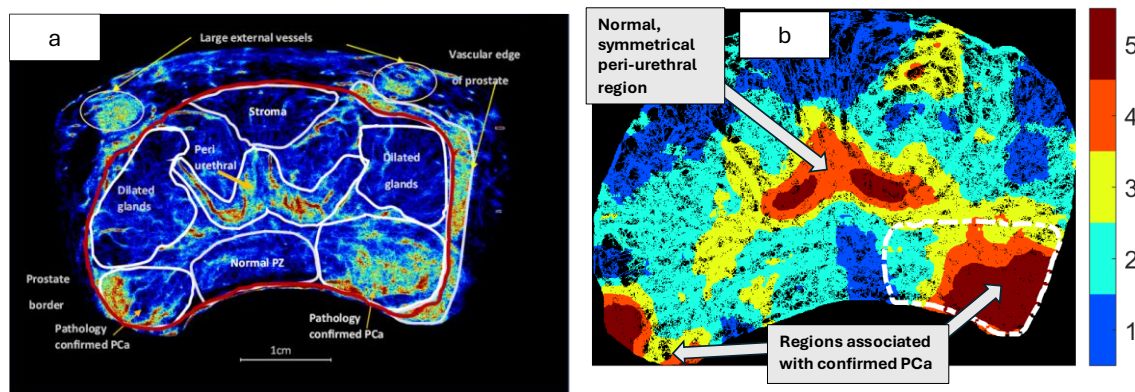
In addition to collecting the clinical data, work was undertaken to improve the patient protocol and the algorithms used in the processing of the collected data. The results show that the new imaging technology is feasible in detecting prostate cancer using validated histopathological evaluation. The results show potential for non-inferior sensitivity and specificity to the current standard of care, at a much lower price as well as avoiding a separate appointment with the radiology department. The study protocol is considered user friendly to be tested with conscious patients upon presentation to the Urology department in a larger study that will compare its performance at its allocated patient pathway position.





WHAT WERE THE RESULTS AND WHAT DO THEY MEAN?

Super resolution images created from the data display the distribution of blood vessels the entire vascular tree within the prostate to including the smallest blood vessels (figure a). As well as the structure of the blood vessels, information such as how much blood or how fast the blood is flowing can be found. Patterns identified in the images demonstrated features of blood flow in the smallest vessels and vessel structure (vessel density, vessel tortuosity, heterogeneity, entropy, fractal dimension, blood flow and velocity) which correlated with cancer with statistical significance. The detail and resolution of the images are unlike any radiological imaging of the prostate seen to date. A further step was the initial assessment of the feasibility of creating an automatic scoring system by combining outputs and creating a grading system indicating likelihood of cancer across the whole prostate image (figure b).



This algorithm was not originally planned but it was deemed necessary to generate a scoring system similar to the current standard of care (MRI imaging) that enables the assessment of the diagnostic accuracy of the super-resolution maps.

Figure Part a) a super resolution ultrasound image (representing blood flow in the prostate) shows the regions of cancer, confirmed by pathology. Part b) heat map providing a scoring system across all areas of the prostate image. Grade 4 and 5, when not located in a region of known normal prostate structure indicates region of high likelihood of cancer which was confirmed by pathology.



WHAT IMPACT COULD THE FINDINGS HAVE?

The findings from this work provide an important feasibility and validation study showing the potential for using super resolution ultrasound as a tool in the current prostate clinical pathway. This tool could compliment or potentially replace MRI in identifying regions for biopsy in the prostate cancer diagnostic pathway.

Main impacts of the funding:

The current results are encouraging and our initial assessment shows that the use of super-resolution ultrasound imaging may reduce prostate cancer related mortality, reduce biopsy, simplify patient management pathway, and provide an effective prostate monitoring as well as a prostate treatment planning tool. If these indeed prove successful, it is then possible to investigate the application of super-resolution ultrasound for prostate screening.





HOW WILL THE OUTCOMES BE DISSEMINATED?

Some results from the study have been presented at conferences with some associated publications, listed below. In addition a full journal paper covering all results is under preparation and will be submitted on completion.

The next steps will be to seek funding to undertake a large development trial where participants are scanned before they have a cancer diagnosis, in order to assess the position of the method in the clinical pathway in diagnosing prostate cancer, at this point we will include PPI discussions and feedback. Note, that the current work did not involve a substantiation PPI component, given that the patients were anaesthetised and could provide full feedback on the procedure.

Conference Presentations

K Gallagher et al Prostate super-resolution ultrasound imaging: A world first experience of near-microscopic depiction of normal and abnormal tissue domains presented March 2025

G Papageorgiou et al Multiparametric imaging biomarkers using super resolution ultrasound: A feasibility scoring system for prostate cancer presented March 2025

British Medical Ultrasound Society annual meeting

M Butler et al Feasibility of using super-resolution ultrasound imaging for prostate cancer Presented December 2024

IEEE International Symposium on Biomedical Imaging

M. Butler *et al.*, "Feasibility of a Vascular-Specific Super Resolution Ultrasound Algorithm for Prostate Cancer Imaging," *2024 IEEE International Symposium on Biomedical Imaging (ISBI)*, Athens, Greece, 2024, pp. 1-4, doi: 10.1109/ISBI56570.2024.10635292.

A. Mobberley *et al.*, "Super Resolution Ultrasound Imaging Biomarkers in Prostate Cancer," *2024 IEEE International Symposium on Biomedical Imaging (ISBI)*, Athens, Greece, 2024, pp. 1-4, doi: 10.1109/ISBI56570.2024.10635689.



CONCLUSION

The preliminary study demonstrates that super resolution ultrasound imaging of the prostate is a feasible method for identifying prostate cancer in instances of known prostate cancer. Images at a histological scale, depicting the vascular structure and function of blood vessels within the prostate, can be created using ultrasound imaging. These images correlate with the presence of prostate cancer as well as show normal features and other pathology. The diagnostic sensitivity and specificity is non-inferior to the current standard of care, although the statistical power of a larger study would be required to confirm this. The results here open the way for future trials assessing clinical insertion points as a potential highly cost-effective diagnostic tool. As a tool in prostate cancer imaging this method may be more accessible to patients where there are long waits for MRI scans, it could be provided within the urology department. While it is still invasive in terms of having an IV and transrectal ultrasound exam it has the potential to be applied at the same time and place as a prostate biopsy might be undertaken enabling fewer clinical visits.



RESEARCH TEAM & CONTACT



NAME(S) Vassilis Sboros

Institution: Heriot-Watt University



Email address: V.Sboros@hw.ac.uk