Survey of current practice in clinical transvaginal ultrasound scanning in the UK

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Abstract

During transvaginal ultrasound scanning, the fetus and other sensitive tissues are placed close to the transducer. Heating of these tissues occurs by direct conduction from the transducer and by absorption of ultrasound in the tissue. The extent of any heating will depend on the equipment and settings used, the duration of the scan, imaging modes and other aspects of scanning practice. To ensure that scans are performed with minimum risk, staff should have an appropriate knowledge of safety and follow guidelines issued by professional bodies.

An online survey aiming to document current practice in transvaginal ultrasound in the UK was created and distributed to individuals performing this type of scanning. The survey posed questions about the respondents, the departments where scans were performed, the equipment used, knowledge of ultrasound safety, scanning practice and the frequency, duration and mode of transvaginal ultrasound scans for gynaecology, obstetrics and fertility applications. In all, 294 responses were obtained, mostly from sonographers (94%). From the analysis of the responses, it was clear that there was a good understanding of the general meaning of thermal and mechanical index and high awareness of guidelines issued by professional bodies. However, 40% of respondents stated that they rarely or never monitor Thermal or Mechanical indices during scanning. Scanning practice was consistent in terms of the duration of scans, scan protocols followed and use of imaging modes. The results highlight the importance of continued ultrasound safety training and promotion of safety guidelines to users.

Keywords: Ultrasound safety, obstetrics, gynaecology, transvaginal ultrasound, thermal effects, clinical practice

Ultrasound 2015; **23**: 138–148. DOI: 10.1177/1742271X15582288

Introduction

Ultrasound is extremely widely used for diagnostic medical imaging; almost 10 million ultrasound examinations were performed by the NHS in England between April 2013 and March 2014. Almost 2.9 million of these scans were obstetric scans.¹ In a small survey which aimed to provide a snapshot of exposure conditions during ultrasound scans performed in one day in February 2007, of the figures returned, 21 scans were classified as transvaginal, compared to 231 obstetric scans.² It is not known what fraction of the transvaginal scans reported were obstetric and how many were for other applications. Data on the number of transvaginal scans performed for non-obstetric applications and the fraction of obstetric scans that are performed transvaginally, rather than transabdominally, are not available. The fetus and tissues imaged during transvaginal ultrasound scans (TVUS) are sensitive to thermal damage and will be placed close to the transducer during scanning. Heating of these tissues is therefore possible due to absorption of the

ultrasound by the tissue and from direct heat transfer from the transducer surface. It is advised by the European Federation for Ultrasound in Medicine and Biology (EFSUMB) that as there is a lack of long-term follow-up studies on the use of ultrasound in the first trimester, care is required when using TVUS in early pregnancy.³

Transducer surface temperature rises of up to 6°C are permitted for endocavitary probes under International Standards;⁴ safety guidelines issued by the British Medical Ultrasound Society (BMUS) recommend that when there is a Thermal Index (TI) of between 2.5 and 3.0, the scan time should be limited to less than 1 minute;^{5,6} the World Federation of Ultrasound in Medicine and Biology (WFUMB) formerly advised that temperature rises of 4°C or more for 5 minutes should be considered potentially hazardous,⁷ but now refer to the BMUS guidelines based on Thermal Index values.⁸

Maximum acoustic output levels set by the FDA were relaxed in the early nineties under the output display standard,⁹ which allows equipment to deliver a spatial-peak

temporal-average intensity (I_{SPTA}) of up to 720 mW/cm² for all applications except for ophthalmic, when previously there was a much lower limit of 94 mW/cm² for fetal applications. This increase is permitted provided that Mechanical Index (MI) and TI are displayed on screen to allow the user to estimate the risk of mechanical and thermal bioeffects during scanning. Responsibility has therefore been placed on the user of the ultrasound equipment, with the requirement that they understand the risk of ultrasound bioeffects indicated by the displayed MI and TI and that they use this information appropriately. Upward trends in acoustic output levels of diagnostic ultrasound equipment have been reported since this time.^{10,11}

The thermal index is expected to be higher when Doppler modes are used, and may change depending on the ultrasound frequency, power levels and many of the scan settings, for example, depth, write zoom, position and size of spectral Doppler gate and colour flow Doppler window. The exposure to the patient during an ultrasound scan will therefore be dependent on how the scan is performed and as default machine settings can vary significantly,¹² this may vary from user to user and from machine to machine. If ultrasound machines are not operating optimally, this could lead to increased acoustic output to achieve the same image quality or to longer scan times. In addition, thermal index does not take into account heating due to transducer surface self-heating and this can be important during endocavitary scans, where heat cannot be lost to the air and sensitive tissues are in close proximity to the transducer. Models have shown that a 6°C temperature rise at the surface after 200 seconds could give rise to a temperature rise of 1°C at a depth of 1 cm in tissue where there may be fetal tissue present.¹³

As we have previously mentioned, the BMUS safety guidelines recommend limiting scan times based on the displayed TI and the WFUMB advises that 'users should remain aware of both indices while scanning, especially when changing scan modes and should adjust the machine controls to keep them as low as reasonably achievable (ALARA principle) without compromising the diagnostic value of the examination' and that for obstetric applications, default power settings should result in a maximum TI of 0.7.⁸ Despite these recommendations, some authors have shown that many users of clinical diagnostic equipment are not completely familiar with the concepts of TI and MI or use them as intended,^{14,15} and that there are a significant number of users who think unrestricted use of ultrasound in the 1st trimester of pregnancy is acceptable.¹⁶ It appears that there are no specific safety recommendations relating to the use of transvaginal ultrasound for non-obstetrical applications. Data from some manufacturers of ultrasound machines on maximum MI and TI suggests that some machines are designed to operate with MIs up to the FDA limit of 1.9 and while maximum TI values are generally around 2, there are some outliers where the maximum TI equals or exceeds the FDA limit of 6.¹⁷ In this context it is especially important that displayed MI and TI values are monitored.

The survey described in this paper is part of a larger project which aims to study the safe use of clinical TVUS

by documenting current and past exposure levels in TVUS for obstetrical, gynaecological and fertility applications and to investigate the temperature rise occurring during routine scanning (UK Department of Health project number 091/0206: TVUS – hazard and clinical practice). Any potential risk to the fetus and other sensitive tissues from TVUS will depend on the ultrasound scan settings, modes used and duration of exposure. The scans should be performed in such a way that minimises this risk and this depends on the practice of the user of the equipment and their awareness of ultrasound safety and use of relevant guidelines and protocols. The specific aim of this survey was to build up a picture of the way in which TVUS is performed at present in the UK by individual users in order to document current safe practice.

Methods

A survey was conducted to document current practice in this type of scanning by individual users in the UK at present. The survey contained 45 questions (available with the online version of this article at <http://ult.sagepub.com>) divided into sections requesting information on the respondent, the department they work in, their approach to ultrasound safety and the number of scans, duration and modes used for scanning for gynaecology, obstetrics and fertility applications. The survey was aimed at individual users of clinical transvaginal ultrasound equipment and the aim was to obtain answers from people working in a variety of different types of clinic both in the NHS and the private sector from across the UK. The questions were mainly multiple choice with few free text fields as it was thought that this would make the survey less time consuming to answer and would enable easier grouping of the responses.

The survey was hosted on [surveymonkey.com](http://www.surveymonkey.com) (www.surveymonkey.com/s/NPL-TVUS). It was publicised by the Society and College of Radiographers (SoR) via email, newsletter and their website, by BMUS via digital newsletter, and the websites of the Royal College of Midwives, Royal College of Nursing (RCN) Fertility Nurses Group, and the Facebook page of the International Society for Ultrasound in Obstetrics and Gynaecology (ISUOG). The survey link was also sent directly by email to a number of private ultrasound clinics and other centres.

Results

In total there were 294 responses to the survey; 94% of these responses were from sonographers. As the numbers of responses from other professional groups (obstetricians, gynaecologists, radiologists, nurses and midwife sonographers) were very small, the data are not included in this paper as the samples were not large enough to provide a representation of these groups as a whole but rather represent the individuals who answered the survey. However, the full results are available to view with the online version of this article at <http://ult.sagepub.com>. Some details of free text comments provided in addition to the multiple-choice answers are given here where the responses could

be grouped appropriately and common themes were apparent.

People and scanning locations

All data shown here were taken from respondents who gave their job title as Sonographer. The majority of respondents were employed by the NHS; 5% of the respondents stated that they were employed by both the NHS and by private clinics or through an agency; 10% of respondents stated that they were employed solely in the private sector; 80% of the respondents had been working in ultrasound for more than 10 years with only 1% having worked in ultrasound for less than 2 years. The majority (80%) of these held a Postgraduate Diploma in Medical Ultrasound, while 19.5% held an MSc in Medical or Clinical Ultrasound either alternatively or additionally and 13% held a Postgraduate Certificate in Medical/Clinical Ultrasound.

For questions relating to the centre where the respondents perform transvaginal scans they were asked to answer only for the centre where they spend most of their time scanning, as it was recognised that people may work in different clinics or departments. Most respondents (54%) spent most of their time scanning in NHS obstetrics and/or gynaecology units; the next most common department was an NHS general ultrasound unit (22%); 9.5% of respondents spent most time scanning in private diagnostic or screening ultrasound clinics with the remaining split between NHS radiology departments, women's health, early pregnancy, fetal medicine and NHS and private sector fertility units. Several of the respondents specified that they worked in multiple departments including the specialist NHS units. The centres at which the respondents spent their time scanning were distributed across the UK; the geographical distribution is mapped in Figure 1.

Most departments had 6 to 10 full time equivalent staff performing TVUS (estimated mean 9 staff). In most cases (83%), scans were 'always' or 'almost always' performed by sonographers but were 'often' or 'sometimes' performed by obstetricians, gynaecologists, radiologists, nurses or midwife sonographers.

Equipment and maintenance

The survey asked about the equipment that was used for TVUS. The majority of the departments that the responses originated from seem to be fairly large departments. In all, 44% of the respondents had 4–6 machines in their centre that were used for TVUS with 39% of centres having seven or more ultrasound machines (Figure 2). Fewer responses were obtained from users who worked in smaller departments or clinics.

To obtain more detail about the range of different machines used across the UK, respondents were asked to give the number, make and model of up to four different models of ultrasound machines used in their departments. From this information (where multiple responses appeared to originate from the same department, only one was taken to avoid duplication), an estimate of the proportion of machines from the main ultrasound manufacturers was made. The most common manufacturer appeared to be

Toshiba (37.4%), followed closely by GE Ultrasound (33%). There were smaller numbers of Philips and Siemens machines with 15% and 8.3%, respectively. The remaining machines were made by Aloka, Hitachi and Sonosite. Some models or series of machines were particularly common. Of the Toshiba machines, the Aplio series was the most popular with 69% of these machines being from this series and 21% were given as the Xario model. Of the GE machines, 71% were from the Voluson series while 22% were the Logiq model. Details of the common models are given in Table 1.

The users of the equipment should be confident that the machines are suitable for the clinical purpose. An awareness of how the machines are maintained seems important in this context. To obtain information about how often these quality assurance procedures are performed and the staff group that perform them, several questions were asked. Of the respondents, 89.5% said they were aware of maintenance or quality assurance procedures performed on the ultrasound machines they used and that these were performed by an external organisation (i.e. not part of the hospital or clinic) (48%), medical physics department (34%) or sonographers (17%). In the remaining cases it was not known who performed maintenance or quality control procedures. The survey then asked about the frequency with which different QA tests (image quality, element drop out, calliper accuracy, Doppler QA, output power measurement and electrical safety testing) were performed; the results are presented in Figure 3. In many cases the frequency with which QA tests were performed was not known. Where it was known, most were performed either yearly or 3 to 6 monthly. Element drop-out, calliper accuracy and image quality tests were reported to take place more frequently (monthly or weekly) by some users. Few users (up to 5% for each test) reported that QA procedures were performed on acquisition of the machines. Some users (1%) reported that element drop-out, output power measurements and electrical safety tests had never been performed on their machines and 5% reported that Doppler QA tests had never been performed.

Ultrasound safety and scanning practice

A section of the survey was concerned with the users' understanding and approach to ultrasound safety. Several questions were asked about the users' understanding of mechanical and thermal indices as indicators of potential risk during scanning, about safety guidelines that they follow and how and why they make adjustments to scan settings during scanning. Overall, understanding of mechanical and thermal indices was good; almost all users claim to follow safety guidelines but only a third of the respondents 'always' or 'often' monitor MI and TI while scanning.

When asked what they understood by Thermal Index, 91% said they understood that it was related to the potential for thermal bioeffects, while 8.5% said just that it was related to safety. One respondent stated that they knew it was displayed on the ultrasound machine but did not know what it meant. For mechanical index, 79.5% said they understood it was related to the potential for mechanical

Figure 1 Map of UK locations where respondents are based. Map data: ©2015 GeoBasis-DE/BKG (©2009) Google.

bioeffects, while 17% said they understood that it was related to safety. The remaining respondents stated that either they knew it was displayed on the machine but were not sure exactly what it meant or that they were not sure what it was at all. Users were also asked whether they monitor the MI and TI while they are scanning (Figure 4); 12% and 13% said that they always monitored the MI and TI, respectively, during scanning, while 14% and 13% said they never monitored MI or TI. The respondents were also given the chance to supply extra comments to this question. Many of those that provided comments said that they followed the ALARA principle or that they used preset imaging configurations (presets) that were set up to keep the MI and TI at a low level. Some users said that they monitored the TI and MI more carefully during early pregnancy scans than during scans performed for other reasons.

Some people assumed that the manufacturer would have set the machine up so that the MI and TI would always be low but others said that they did not realise it was important to monitor MI and TI or that they thought it was the responsibility of physics staff when performing QA to ensure the levels are low.

Almost all respondents followed safety guidelines; these were most commonly the guidelines issued by BMUS. Fifty percent of the respondents said that they also followed guidance specifically related to TVUS issued by the Royal College of Obstetricians and Gynaecologists (RCOG), the SoR and the ISUOG.

Presets are commonly selected at the start of an examination to ensure the initial settings are appropriate for the type of scan. Changing the depth, frequency, zoom and mode will influence the TI. The questions in this section

Figure 2 'How many ultrasound machines are used for TVUS in your department or clinic?' n = 220

Table 1 Frequency of machines by manufacturer and by common model for each manufacturer

Manufacturer	Percentage by manufacturer	Model	Percentage by model for each manufacturer
Toshiba	37.4%	Aplio series	69%
		Xario	21%
GE Ultrasound	33.0%	Voluson series	72%
		Logiq	22%
Philips	15.0%	iU22 xMATRIX	61%
		HD series	28%
Siemens	8.3%	Acuson S	54%
		Acuson Antares	26%
Aloka	5.4%	Prosound Alpha	41%

relate to use of presets during scanning. All respondents used presets when scanning and most (82%) selected different ones according to the specific examination they were performing; 94.5% of people said that once the preset had been selected they 'often' adjusted the settings. The most common reasons for adjusting scan settings were to 'optimise the position of structures in the image' and 'to improve the visibility of structures in the image' with 91% and 82% giving these reasons, while only 13.5% stated that they adjusted the settings 'because of the displayed MI or TI'.

Exposure to the patient can be minimised by keeping scan times to a minimum and also by turning off the output when a live image is not required.⁵ If the probes are removed from the patient then their exposure is obviously reduced but the probe can self-heat when running in air. Although it is unlikely that the probe would be removed during a transvaginal scan, the probe may be left running between patients. This can be a source of thermal hazard, which is especially important in transvaginal scanning

where sensitive tissues and the fetus can be in close proximity to the transducer.

The survey asked about use of the freeze function; 74.5% said that they often use the freeze function when there is no need to see a live image. The remaining said they rarely use it except during measurements or in order to review a cine loop. Between patients, almost all users either returned to the menu screen during which time the output was switched off automatically or they used the freeze function at the end of the examination before returning to the patient set-up menu.

Number, duration and mode of scans

TVUS may be performed for a large number of reasons. The duration of scans may vary from a few minutes, where the scan is to confirm findings from a transabdominal scan, to up to 20 to 30 minutes for a full investigation of pelvic anatomy. Scans may be performed for reasons that fall broadly under gynaecology, fertility and obstetric applications. In the previous section relating to the users approach to safety, people commented that they would be more likely to monitor TI and keep scan times short for early pregnancy scans. As the scan times and imaging modes used may vary depending on the application, the respondents were asked to answer questions separately for each application.

Almost all respondents performed scans for gynaecology applications; the next most common application was obstetrics, while only half performed scans for fertility applications. This breakdown is shown in Figure 5. The results showed that among these users, most scans were performed for gynaecological applications with almost half of those performing these scans doing more than 50 per month. Where users scanned for fertility applications, this was generally a relatively low number of scans per month. The number of obstetrical scans performed was distributed more evenly over the range from a few scans per month up to more than 50 scans.

Figure 3 'How often are quality assurance procedures performed on the ultrasound machines available for TVUS in your department or clinic?' n = 197

Respondents were also asked about the duration of scans; they were asked to give an estimate of the usual minimum time taken to perform a scan and the usual maximum time taken. Most users (70%) gave the minimum scan

length as 5 minutes (which was the shortest option offered) for all applications; for gynaecology and fertility applications approximately 30% of users gave 10 minutes as a minimum scan time. The maximum scan times given had a

Figure 4 'Do you monitor TI and MI while you perform TVUS?' n = 220

Figure 5 Left: 'Do you perform TVUS scans for gynaecology/obstetrics/fertility?' n=217. Right: 'Approximately how many TVUS scans do you perform for gynaecology/obstetrics/fertility in an average month?' n=210, 172, 102

larger spread but were centred around 10 to 15 minutes, with 12%, 11% and 7% (gynaecology, obstetrics, fertility) of users reporting the maximum duration as 25 minutes or more; the data are shown in Figure 6.

Users were also asked if they followed scan protocols when performing TVUS. As can be seen in Figure 7, for all three applications, most users were either required to or preferred to follow protocols (either local or issued by a professional body) rather than scan according to their own experience. Free text comments indicated that these were in many cases local protocols that were based on the recommendations of the UK Association of Sonographers, RCOG, ISUOG, BMUS and NICE.

As well as B mode, Doppler modes may be used during TVUS. The survey asked how often modes other than B

mode might be used; the responses are shown in Figure 8. Colour or power Doppler was the most frequently used, and appears to be used more often during scans for gynaecology with 55% of respondents 'always' or 'often' using this mode for gynaecology in contrast to 30% for obstetrics and 36% for fertility. Pulsed wave Doppler is used much less frequently with only 10% using it 'always' or 'often' for gynaecology, 11% for obstetrics and 7% for fertility. 3D imaging is never used by a large proportion of the respondents – 75% for gynaecology and fertility and 87% for obstetrics.

Users were also asked about the recording of ultrasound scans; images may be stored for reporting purposes or reassurance for patients among other reasons. For all scan types, 98% of the respondents recorded part of the scan in

Figure 6 'Approximately how long do these scans take to perform?' Approximate maximum scan durations for gynaecology, obstetrics and fertility

Figure 7 'When performing routine scans, which of the following most closely describes your practice?' (a) gynaecology, n = 210; (b) obstetrics, n = 170; (c) fertility, n = 98

some way. Digital still images were the most common form of recording, followed by hard copy snap shots.

Discussion and summary

The survey and results described in this article aim to create a snapshot of current practice in clinical TVUS in the UK. Responses were obtained from sonographers from across the UK working in different types of clinics, mainly within the NHS. The majority of the respondents had more than 10 years' experience in ultrasound and hold post-graduate qualifications in ultrasound. It was reported that sonographers were the staff group most often performing TVUS.

More than a third of the departments that responses were received from had seven or more ultrasound machines that were used for TVUS. Toshiba and GE were the most common manufacturers, and the Toshiba Aplio and GE Voluson were the most common models. Most of the survey respondents indicated that they were aware of quality assurance or maintenance procedures on their machines. In 20–30% of responses, the frequency with which the tests were performed was not known. For those who did give an estimate of the frequency, common responses for all of the checks asked about were yearly and 3–6 monthly. This is contradicted by data from a small number of medical physicists (see Table 2) contacted alongside this survey which indicated that in many centres Doppler QA and acoustic

Figure 8 'In addition to B mode imaging, what other modes do you use during these scans?'

Table 2 Estimated frequency of quality assurance tests performed from data provided by UK medical physicists; n = 14

Frequency test type	Do not know	Never	On acquisition	Less than yearly	Yearly	3–6 monthly	Monthly	At least weekly
Image quality	0	2	4	0	6	1	1	0
Element drop out	0	1	0	0	4	2	6	1
Measurement tools	1	2	3	0	5	1	2	0
Doppler QA	0	11	1	0	2	0	0	0
Output power	0	11	1	1	0	0	1	0
Electrical safety	2	0	2	0	7	3	0	0

output measurements are never performed. The data also suggests that other checks are often performed either on acquisition or yearly by a combination of medical physics and engineering staff, sonographers and under external maintenance contracts.

It is recommended by BMUS and the Institute of Physics and Engineering in Medicine that quality-assurance procedures are performed on diagnostic ultrasound systems to ensure that they are fit for purpose. Daily checks for transducer element drop-out by sonographers are recommended. This can be done easily by running the transducer in air and inspecting the resulting reverberation pattern.¹⁸ There are other checks that can be done without test tools such as image quality phantoms, for example monitoring of noise levels and visual inspection of transducers and cables for electrical safety reasons. These checks are recommended to be performed on a monthly basis and any problems detected can then be investigated further by appropriate medical physics or engineering personnel. Acoustic output measurements and Doppler quality assurance are suggested but it seems that few hospitals have the equipment or staff to perform these.

There was a high awareness of the general meaning of TI and MI. However, there were a few responses that showed a lack of understanding of mechanical and thermal indices and that they are intended as an indicator to the user and should therefore be monitored during scanning. There was high awareness of professional guidelines with almost all respondents stating that they follow safety guidelines and scan protocols issued by a number of organisations, all of which require users to have an understanding of ultrasound safety and potential bioeffects. Some of the guidelines place more emphasis on clinical protocols to be followed when performing scans for different indications, but do also specify that the practitioner should have an understanding of safety. This includes an awareness of the acoustic output and thermal index during scanning. The safety guidelines issued by BMUS give recommended maximum scan times at particular thermal indices. The TI should be monitored in order to adhere to these. Just over 40% of the respondents said that they rarely or never monitor the MI or TI while scanning. Text comments indicated that people were more aware of safety during early pregnancy scans. Other comments suggested that machine settings are used that keep the TI and MI to a minimum. The use of Doppler modes where the TI may be increased is kept to a minimum. Pulsed wave Doppler is rarely used by many

respondents. Colour flow Doppler is used by a third to a half of the respondents depending on the scan type, but for short times.

The results show that scans seem to be performed in a fairly standard way across the country. Standard scan protocols are widely used and although they may be locally written, they are based on guidelines issued by national organisations. The duration of examinations was similar for scans performed for gynaecology, obstetrics and fertility, which on average lasted for an estimated 8 to 15 minutes. This is consistent with data collected by the SoR which showed early pregnancy and gynaecology scans were usually allotted 15 to 20 minutes.^{19,20} Most of the scans are performed by sonographers with some occasionally performed by other staff groups including obstetricians, gynaecologists and radiologists. Again this is consistent with the findings of the SoR.

Although on average the estimates of scan durations were similar for all three applications, it can be seen from the data that there is a bias towards shorter scan times for obstetrics. It has been stated in answers to other parts of the survey that the users are more safety conscious during obstetrical scans so this may have some influence over scan duration. It may also be due to the nature of the scans and the number of features that need to be imaged during scans for gynaecology and fertility. Guidelines and recommended protocols issued by the RCN or the SoR give details of the anatomy that should be investigated, and make some reference to ultrasound safety. These will both affect the scan times if scans are performed according to this guidance.

The BMUS guidelines state that the use of pulsed wave Doppler and colour Doppler with a narrow write zoom box is not recommended in early pregnancy unless the TI is monitored and there is some benefit that outweighs the risk to the embryo.⁵ The RCN suggests that blood flow characteristics of ovarian masses should be investigated with pulsed wave Doppler.²¹ Guidelines issued by the UK Association of Sonographers suggest that use of colour flow or power Doppler may be appropriate in situations including the following: 'the assessment of myometrial vascularity, ovarian angiogenesis, endometrial vascularity'²² and that 3D ultrasound should be considered for investigating uterine and ovarian pathology and congenital conditions. Follow-up questions were sent to a sample of the respondents (n = 12) to ask for more information on the length of time that these modes might be used for.

These answers indicated that colour or power Doppler may be used 2 or 3 times during a scan for periods of up to 30 seconds at a time. Pulsed wave Doppler is very rarely used; on the occasions that it is, it is usually for 20 to 30 seconds.

Conclusions

Overall the survey results give a good picture of current practice in TVUS among sonographers in the UK. It would be useful to collect more data from other staff groups to see if there are any differences in the way TVUS is performed. Guidelines and standard protocols are heavily used so practice would be expected to be consistent. Conflicting answers from sonographers and medical physics staff regarding quality assurance and maintenance procedures suggest that sonographers should not assume that the performance of their machines is regularly checked and should look out for problems themselves. Although general understanding of thermal and mechanical indices was high, the fact that some people were not aware of their meaning or intended use and 40% rarely or never monitored them while scanning highlights the need and importance of continued training in ultrasound safety.

DECLARATIONS

Competing interests: The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health. Any mention of commercially available ultrasound equipment should not be seen as an endorsement.

Funding: This report is independent research commissioned and funded by the Department of Health Policy Research Programme (Transvaginal Ultrasound Scanning – Hazard and Clinical Practice, 091/0206). Christoph Lees is supported by the National Institute for Health Research (NIHR) Biomedical Research Centre based at Imperial College Healthcare NHS Trust and Imperial College London.

Ethical approval: As the survey was a voluntary audit, ethical permission was not required.

Guarantor: EM

Contributorship: EM and AS designed and wrote the survey questions. All authors reviewed and approved the final survey questions. EM implemented the survey on surveymonkey.com, did the data analysis and wrote the manuscript. All authors reviewed and approved the final version of the manuscript.

ACKNOWLEDGMENTS

The authors thank the organisations who advertised the survey on our behalf and those who participated in the survey.

REFERENCES

1. NHS England Analytical Services. *NHS imaging and radio diagnostic activity 2013/14 Release*. 2014. See <http://www.england.nhs.uk/statistics/wp-content/uploads/sites/2/2013/04/KH12-release-2013-14.pdf> (last checked 24 Mar 2015)
2. Ter Haar G. Results of a survey of exposure conditions used in ultrasound scans in the UK, February 2007. *Ultrasound* 2008;**16**:110–3
3. Ter Haar G (ed.). *The safe use of ultrasound in medical diagnosis*, 3rd ed. London: The British Institute of Radiology, 2012
4. International Electrotechnical Commission. *IEC 60601-2-37 Medical electrical equipment – Particular requirements for the safety of ultrasonic medical diagnostic and monitoring equipment*. Geneva: IEC, 2005
5. Safety Group of the British Medical Ultrasound Society. *Guidelines for the safe use of diagnostic ultrasound equipment*. 2009. See <http://www.bmus.org/policies-guides/BMUS-Safety-Guidelines-2009-revision-DETAILED.pdf> (last checked 24 Mar 2015)
6. Safety Group of the British Medical Ultrasound Society. *Guidelines for the safe use of diagnostic ultrasound equipment*. *Ultrasound* 2010;**18**:52–9
7. WFUMB. WFUMB symposium on safety of ultrasound in medicine recommendations on the safe use of ultrasound. *Ultrasound Med Biol* 1998;**24**(Supplement 1): xv – xvi
8. WFUMB Safety Committee. WFUMB clinical safety statement for diagnostic ultrasound 2012. See <http://www.wfumb.org/about/statements.aspx> (last checked 24 Mar 2015)
9. AIUM/NEMA. *Standard for the real time display of thermal and mechanical acoustic output indices on diagnostic ultrasound equipment*. Virginia: NEMA, 1992
10. Duck FA, Martin K. Trends in diagnostic ultrasound exposure. *Phys Med Biol* 1991;**36**:1423–32
11. Henderson J, Willson K, Jago JR, et al. A survey of the acoustic outputs of diagnostic ultrasound equipment in current clinical use. *Ultrasound Med Biol* 1995;**21**:699–705
12. Dudley N, Gibson N. A case study in scanner optimisation. *Ultrasound* 2014;**22**:21–5
13. Calvert J, Duck F, Clift S, et al. Surface heating by transvaginal transducers. *Ultrasound Obstet Gynecol* 2007;**29**:427–32
14. Sheiner E, Shoham-Vardi I, Abramowicz JS. What do clinical users know regarding safety of ultrasound during pregnancy? *J Ultrasound Med* 2007;**26**:319–25
15. Akhtar W, Arain M, Ali A, et al. Ultrasound biosafety during pregnancy: what do operators know in the developing world? National survey findings from Pakistan. *J Ultrasound Med* 2011;**30**:981–5
16. Houston LE, Allsworth J, Macones GA. Ultrasound Is Safe ... Right? *J Ultrasound Med* 2011;**30**:21–7
17. Martin K. The acoustic safety of new ultrasound technologies. *Ultrasound* 2010;**18**:110–118
18. Dudley N, Russell S, Ward B, et al. BMUS guidelines for the regular quality assurance testing of ultrasound scanners by sonographers. *Ultrasound* 2014;**22**:8–14
19. The Society and College of Radiographers. *Ultrasound examination lengths survey analysis*. 2012. See http://www.sor.org/sites/default/files/document-versions/2012%2004%2019%20Ultrasound%20examinations%20survey%20analysis%20with%20questions%20CD%20v2_2.pdf (last checked 24 Mar 2015)
20. The Society and College of Radiographers. *Gynaecological ultrasound survey analysis*. 2011. See http://www.sor.org/system/files/document-library/public/sor_gynae_ultrasound_survey_analysis_CD.pdf (last checked 24 Mar 2015)
21. Royal College of Nursing. *Transvaginal ultrasound scanning: RCN guidance for fertility nurses*. 2006. See http://www.rcn.org.uk/_data/assets/pdf_file/0006/566079/004581.pdf (last checked 24 Mar 2015)
22. United Kingdom Association of Sonographers. *Guidelines for professional working standards: ultrasound practice*. 2008. See <http://www.sor.org/learning/document-library/guidelines-professional-working-standards-ultrasound-practice> (last checked 24 Mar 2015)