An introduction to contrast enhanced spectral mammography

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Introduction

Contrast enhanced spectral mammography (CESM) is a new technology, gaining acceptance throughout Europe and the USA, but only recently introduced to the UK. GE Healthcare is currently the only UK vendor of CESM, using the brand name Senobright. In this article, we will explore the theory behind the technology and the practicalities of performing the test. A brief literature overview is provided, with references for further reading. Real-life examples show representative images obtained with CESM and highlight the added value of using contrast in these cases.

Theory

Most tumours (wherever they arise in the body) exhibit abnormal or increased vascularity and this characteristic can be exploited by giving contrast medium prior to imaging. This is the basis behind the use of iodinated contrast in CT, for example. Breast cancer is typically hypervascular, and those involved in breast imaging will be familiar with the use of contrast (customarily gadolinium) in breast MRI.

The concept of contrast use in x-ray is not new, but in mammography the use of iodinated contrast is problematic. A standard digital mammogram might use target and filter combinations including Molybdenum (Mo) and Rhodium (Rh), at tube voltages between 25 and 34KV. However, the K-edge of iodine is approximately 33KeV and a typical clinical concentration of iodine in the breast would therefore be indistinguishable from the background tissue.

CESM relies on dual energy exposures, acquired during the same compression. The low energy (LE) spectrum, using standard targets and filtration, produces a tube voltage of 26-30kVp. The high energy (HE) component produces tube voltages of 45 to 49kVp (ie above the K-edge of iodine), using target/filter combinations that may include copper (Cu). The radiation dose from a standard CESM procedure is within accepted guidelines for 2D imaging.

CESM in clinical practice

Nottingham Breast Institute (NBI) was the first UK centre to incorporate CESM into its clinical practice, in November 2013. At NBI, we use CESM within our symptomatic breast service. Our indications include:

• First-line imaging (instead of a standard digital mammogram) in symptomatic patients with a breast abnormality, classified clinically as suspicious or malignant (P4/5) in patients aged between 35 and 70 years (the upper age limit is to reduce the risk of contrast-induced nephropathy)
• Second-line imaging (instead of a standard digital mammogram) in symptomatic patients <35 years with a suspicious/malignant abnormality at ultrasound
• For local staging where breast MRI is desirable, but contra-indicated (eg pacemaker)
• In other selected cases, following discussion at multidisciplinary team meeting.

Written informed consent is obtained prior to the examination. Absolute contraindications locally include pregnancy, lactation, iodine allergy, renal failure, inability to give informed consent and inability to tolerate mammography. Diabetes is a relative contraindication, if recent renal function is not available.

A cannula is placed in the back of the hand or in the antecubital fossa and 100mls of Iopamidol 300 is injected via a pump at 3mls/second. Two minutes later, the mammogram is performed. Standard mammographic positioning – cranio-caudal (CC) and medio-lateral oblique (MLO) views – is used, resulting in two sets of images; the LE equivalent to a standard digital mammogram, and the recombined showing areas of contrast uptake within the tissue.

Practical points

• If your breast unit is not located within main x-ray, you will need to acquire a warming cabinet for storage of contrast
• It is possible to hand-inject contrast, but for time purposes and ease of injection, a pump injector is advised
• As this is a new technique, a patient information sheet is recommended
• Seek advice from your trust’s audit and ‘new technologies’ committees – registration may be required
• All staff should have up-to-date anaphylaxis training
• Renal function should be reviewed whenever possible (a checklist to identify those at risk of contrast nephropathy is an alternative).

Recent research

Lobbes et al1 compared CESM measurements against histopathological size, concluding that quality of tumour size measurement using CESM is good. Additional measurements using breast MRI did not improve the quality of tumour size measurements.

Fallenberg et al2 compared CESM with (a) mammography alone and (b) CESM plus mammography, looking at detection and size estimation of histologically proven breast cancers in 118 women. They showed that CESM alone has the same sensitivity and better size assessment as CESM plus mammography and is significantly better than mammography alone. CESM alone had the closest correlation with pathology, whereas CESM plus mammography showed a systematic overestimation of the average lesion size. The authors inferred that this may be because a reader is biased to accept the largest possible measurement on the available images as the actual tumour size. They concluded that when a CESM examination is planned, additional mammography can be avoided, thereby reducing radiation dose.

Hobbs et al1 looked at the patient experience of CESM compared with MRI during preoperative breast cancer staging. A significantly higher overall preference towards CESM was demonstrated, with patients citing faster procedure time, greater comfort and lower noise levels. Participants also reported lower rates of anxiety during CESM compared with CEMRI.
Cheung et al. studied 89 women undergoing both CESM and conventional mammography. CESM provided additional information over mammography, with consistent improvement of cancer diagnosis in dense breasts.

**Potential future applications**
- High-risk screening
- Screening assessment
- Neoadjuvant treatment response assessment.

**Case study A**
A 56-year-old lady presented to our clinic having noticed a lump in her right breast. On clinical examination, this was deemed suspicious and a CESM examination was offered.

Figure 1 (LE images) shows that the tumour in the right upper outer quadrant is very difficult to appreciate.

Figure 2 (recombined images) demonstrates the uptake of contrast within the tumour in the right upper outer quadrant, enabling more accurate size estimation and excluding additional foci.

Ultrasound-guided core biopsy showed invasive carcinoma, core grade 3.

**Case study B**
A 45-year-old lady presented to our clinic with a lump in her right upper breast. On clinical examination, this was deemed suspicious and a CESM examination was offered.

Figure 3 (LE images) shows a predominantly dense background pattern with no focal lesion demonstrated in either breast. Figure 4 (recombined images) shows patchy, glandular enhancement throughout both breasts – this is symmetrical and benign, akin to diffuse glandular enhancement that is sometimes evident at contrast-enhanced breast MRI.

In the area of clinical concern in the right upper midline, is a focal lack of enhancement – this is the 'eclipse sign' of a simple cyst. A cyst was confirmed at ultrasound, and was aspirated to dryness, with resolution of the palpable lump. The patient was reassured and discharged.

**References/further reading**