

# BMJ Open Study protocol for a double blind, randomised, placebo-controlled trial of continuous subpectoral local anaesthetic infusion for pain and shoulder function following mastectomy: SUB-pectoral Local anaesthetic Infusion following Mastectomy (SUBLIME) study

R Langford,<sup>1</sup> I Brown,<sup>2</sup> J Vickery,<sup>3</sup> K Mitchell,<sup>1</sup> C Pritchard,<sup>4</sup> S Creanor<sup>5</sup>

**To cite:** Langford R, Brown I, Vickery J, *et al.* Study protocol for a double blind, randomised, placebo-controlled trial of continuous subpectoral local anaesthetic infusion for pain and shoulder function following mastectomy: SUB-pectoral Local anaesthetic Infusion following Mastectomy (SUBLIME) study. *BMJ Open* 2014;**4**:e006318. doi:10.1136/bmjopen-2014-006318

► Prepublication history and additional material is available. To view please visit the journal (<http://dx.doi.org/10.1136/bmjopen-2014-006318>).

Received 6 August 2014  
Revised 4 September 2014  
Accepted 5 September 2014



CrossMark

For numbered affiliations see end of article.

#### Correspondence to

Dr Roger Langford;  
[roger.langford@rcht.cornwall.nhs.uk](mailto:roger.langford@rcht.cornwall.nhs.uk)

#### ABSTRACT

**Introduction:** Over 16 000 mastectomies are performed in England and Wales annually. Acute postoperative pain and nausea are common. The most frequently occurring long-term complications are chronic pain (up to 50%) and reduced shoulder function (reported at 35%). Regional techniques that improve acute postoperative pain relief may reduce the incidence of these complications. This study assesses the effectiveness of a 24-hour continuous local anaesthetic in the subpectoral plane in improving postoperative pain and quality of life in patients undergoing mastectomy.

**Methods and analysis:** This is a randomised, double blind, placebo-controlled, two-centre, parallel group trial in women undergoing mastectomy with or without axillary involvement. One hundred and sixty participants will be randomised in a 1:1 ratio to receive either 0.25% levobupivacaine or 0.9% saline by subpectoral infusion postoperatively for 24 h. All participants will be provided with an intravenous morphine patient-controlled analgesia (PCA) system. Participants will be followed-up for 24 h in hospital and at approximately 14 days and 6 months postoperatively. Joint primary outcome measures are total morphine consumption and total pain score (captured via patient-recorded visual analogue scale (VAS) 4 hourly) during the first 24 h postoperatively. Primary statistical analysis of total pain is based on the area under the curve of pain versus time graph. Secondary outcomes include PCA attempts in first 24 h; VAS pain scores and shoulder function by goniometry at 24 h, 14 days (approximately) and 6 months; Verbal Rating Scale pain scores in first 24 h; Brief Pain Inventory and Oxford Shoulder Score at 6 months; duration of hospital stay; incidence of postoperative nausea and vomiting; cost-effectiveness.

**Ethics and dissemination:** The study is approved by the South West England Research Ethics Committee (12/SW/0149).

#### Strengths and limitations of this study

- This is a double-blind, randomised, placebo-controlled trial.
- This is the first study to assess the use of a continuous local anaesthetic infusion in the subpectoral plane.
- This is the first study to assess the effects of continuous local anaesthetic infusion on postoperative shoulder function.
- The study includes an assessment of longer term pain.
- All instruments for measuring postoperative pain, including those used in this study, have limitations. We have attempted to address this by using two measures, morphine consumption and visual analogue scale scores, as joint primary outcomes.
- Changing surgical practice means that fewer simple mastectomies are being performed in comparison with breast conservation (wide excision) surgery and skin-sparing mastectomy with immediate reconstruction. This study does not address whether any benefits demonstrated can be extrapolated to these procedures.
- The study does not assess the effects of surgeon variation or duration of surgery on pain and recovery outcomes for patients.
- The study does not assess the level of sedation in the postoperative period. Reduced sedation is a potential benefit of reduced morphine consumption.

**Results:** will be published in a peer-reviewed journal and presented at local, national and international scientific meetings.

**Trial registration:** ISRCTN46621916. EudraCT 2011-005775-16.

## INTRODUCTION

In 2010, the lifetime risk in women of developing breast cancer was estimated as one in eight, with the disease now the most commonly occurring cancer in the UK.<sup>1</sup> Surgery remains the treatment of choice, with around 43% of women with breast cancer opting for mastectomy.<sup>2</sup> A total of 16 595 mastectomies were performed in England and Wales in 2012–2013.<sup>3</sup> The most common complications of mastectomy are postoperative acute and chronic pain and slow recovery of shoulder function. Acute pain in mastectomy patients is currently managed with systemic opiates, either by intramuscular injection or using an intravenous patient-controlled analgesia (PCA) device. Chronic postoperative pain is frequent (20–45%)<sup>4–7</sup> and requires significant use of National Health Service (NHS) resources. Poor recovery of shoulder function, associated with initial poor analgesia, impacts on quality of life long after the initial recovery period.<sup>8, 9</sup> These effects are all the more significant considering the young age at which many patients present.

Postoperative analgesia therefore remains a challenge for these patients despite a range of treatment options.<sup>10</sup> Most postoperative pain in mastectomy occurs within the first 24 h of surgery. Inadequately managed pain in the acute postoperative phase is a major risk factor of chronic pain syndromes,<sup>5</sup> which are present in up to 50% of patients 6 months after operation.<sup>11</sup> Impaired shoulder function also causes significant problems post-mastectomy<sup>12–14</sup> and it has been suggested that better postoperative analgesia may enhance the effects of early physiotherapy. There is no gold standard for pain relief following mastectomy surgery.<sup>10</sup> Morphine, the mainstay of therapy, is associated with vomiting and excessive drowsiness. Thoracic epidural and paravertebral blocks have been shown to provide adequate analgesia,<sup>10</sup> but associated complications (eg, pneumothorax), although rare, are severe and potentially life-threatening. Local anaesthesia wound infiltration has not been adequately studied using randomised controlled trials.<sup>10</sup> An informal survey of current practice in the South West Peninsula of England suggested that its use is patchy and erratic, with a third of surgeons not using any at all and others reporting a range of different methods of administration and doses.

The use of wound catheters to deliver continuous local anaesthetic has been shown to reduce postoperative pain and analgesic requirements in cardiothoracic, orthopaedic and general surgery.<sup>6, 15, 16</sup> The nerve supply to the breast is predominantly from the lateral and anterior branches of the second to sixth intercostal nerves and the supraclavicular nerves.<sup>17</sup> Nerves pass beneath the pectoral fascia before reaching the breast and it is here that local anaesthetic may be deposited via a catheter, as a bolus or subpectoral infusion. The 'Pecs block' was described in 2011<sup>18</sup> as a technique for placing local anaesthesia in the subpectoral plane at the time of surgery. There have since been a number of similar descriptions of ultrasound-guided chest wall local

anaesthetic techniques for use in breast surgery.<sup>19–21</sup> Case reports and small studies indicate that these techniques are efficacious in reducing postoperative pain, however there are, as yet, no large randomised controlled trials. So far these techniques have not been described with the use of continuous local anaesthetic infusion.

Current published research relating to postmastectomy local anaesthesia infusion is scant. A meta-analysis of surgically placed wound catheters concluded that there was a trend towards improved analgesia in the immediate post-operative period, however studies were underpowered and often poorly designed.<sup>22</sup> One randomised study<sup>23</sup> of 42 patients found no significant difference in postoperative analgesia (as measured by PCA use and pain scores) between administration of 4-hourly 20 mL bolus doses of 0.5% bupivacaine and placebo. However, the technique tested involved infiltration via wound drains which deposited local anaesthetic in a more superficial tissue plane than the subpectoral plane and did not use a continuous infusion. Non-randomised, non-blinded, retrospective and observational studies of local anaesthetic infusion<sup>24–26</sup> suggest more favourable results. Baroody *et al*<sup>25</sup> demonstrated a fivefold reduction in analgesic requirement following local anaesthetic infusion after reconstructive breast surgery. Morrison *et al*<sup>24</sup> compared postoperative opioid use in mastectomy patients receiving local anaesthetic infusion or no infusion and found a significant reduction in opiate use and hospital length of stay in the local anaesthetic arm. However, this was an unblinded retrospective analysis and made no attempt to investigate chronic pain or arm mobility. Lu *et al*<sup>26</sup> compared local anaesthetic infusion to placebo in patients undergoing reduction mammoplasty and reconstruction. Results showed reductions in opiate use and pain scores in the local anaesthetic group but controls were historical and the study was unblinded and not randomised. Given the limitations of the study designs, it is currently difficult to make firm conclusions or recommendations for clinical practice. There are no published studies assessing the impact of local anaesthetic infiltration on postoperative shoulder function. There has recently been increased interest in postoperative local anaesthesia for the reduction of chronic pain. A 2012 Cochrane analysis pooled the results of two trials and concluded that paravertebral block may favour the reduction of chronic pain following mastectomy in one in five patients.<sup>27</sup>

Levobupivacaine is the S(-)-isomer of bupivacaine. In common with other local anaesthetic agents, it is widely accepted that levobupivacaine blocks nerve conduction in sensory and motor nerves by blocking voltage sensitive sodium channels in the cell membrane. Levobupivacaine exhibits fewer cardiovascular toxicity effects<sup>28, 29</sup> than bupivacaine and, as such, is safer for use as an infusion. There appears to be no measurable difference in clinical effectiveness between the two agents.<sup>30</sup>

The aim of this study is to establish whether the use of continuous local anaesthetic infusion in the subpectoral

tissue plane can improve postoperative analgesia and quality of life for patients undergoing mastectomy with or without axillary surgery. If the use of this local anaesthetic infusion technique is shown to be more effective than current practice, the reduction of pain and opiate use in the immediate post-operative period would be a significant benefit to patients. The technique also holds the potential to improve patients' quality of life by reducing the longer term risks of chronic pain and impaired shoulder function.

## METHODS AND ANALYSIS

### Study design

The study is a double blind, randomised, placebo-controlled, two-centre, parallel group trial in 160 female patients undergoing mastectomy with or without axillary involvement. The study was originally designed as a single centre study in Cornwall, but audit data prior to the study start confirmed a significant reduction in the number of mastectomies being conducted locally, following changes in the surgical team and surgical practice. In order to achieve the required sample size, the study design was therefore amended to include two study sites. At the same time, an emerging trend for early discharge of patients postmastectomy prompted a change in the timing of primary outcome data collection from 48 to 24 h postoperatively. These changes to the original study design eventually delayed the study start by approximately 10 months.

Participants will be randomly allocated to receive either 0.25% levobupivacaine or 0.9% sodium chloride by subpectoral infusion postoperatively for 24 h. All participants will be provided with an intravenous morphine PCA system. Participants will be followed up for 24 h in hospital and at approximately 14 days and 6 months postoperatively as outpatients.

### Setting and participants

The study is being conducted in breast surgery departments within two NHS Trusts in Cornwall and York, England. The second site was selected after expressing interest in the study and because of its similar mastectomy pathway compared with the lead site. Eligible patients comprise all women presenting for unilateral mastectomy, with or without planned axillary clearance, at one of the participating hospitals. Main exclusion criteria are: primary reconstructive surgery; hypotension or hypovolaemia; allergy or sensitivity to local anaesthetic agents, morphine, paracetamol, ondansetron or cyclizine; daily opioid analgesic use; pregnancy. Study participants are patients who meet the screening criteria and are willing and able to give informed consent.

### Study recruitment

The recruitment process is designed to fit in with routine clinical practice. Potential participants are identified from those attending outpatient breast clinics for

discussion of breast cancer diagnosis and treatment options. Surgery is usually scheduled within a month of the initial clinic appointment, following attendance at a preassessment clinic. Women attending clinic for discussion of prophylactic mastectomy may also be eligible to participate in the study.

Patients for whom mastectomy is a potential treatment option and who appear eligible for the study are given a brief verbal introduction to the study by a clinician or nurse at the initial breast clinic consultation and provided with either a brief written study summary or a full participant information sheet, as deemed appropriate. Patients are subsequently telephoned within a few days by the breast care nurse (or research nurse, depending on local arrangements) and further information about the study is provided verbally and/or by post to patients who express further interest. Patients who are interested in participating in the study are invited to meet the research nurse at the routine preoperative assessment clinic so that any further questions can be answered and eligibility for the study confirmed. Arrangements are made for the patient to discuss aspects of the study with the surgeon or anaesthetist if required. Written informed consent is obtained from patients willing and eligible to participate, by an appropriately trained member of the research team. Patients who decline to take part in the study are not obliged to give a reason for declining but the reason(s) are recorded by the research nurse if provided.

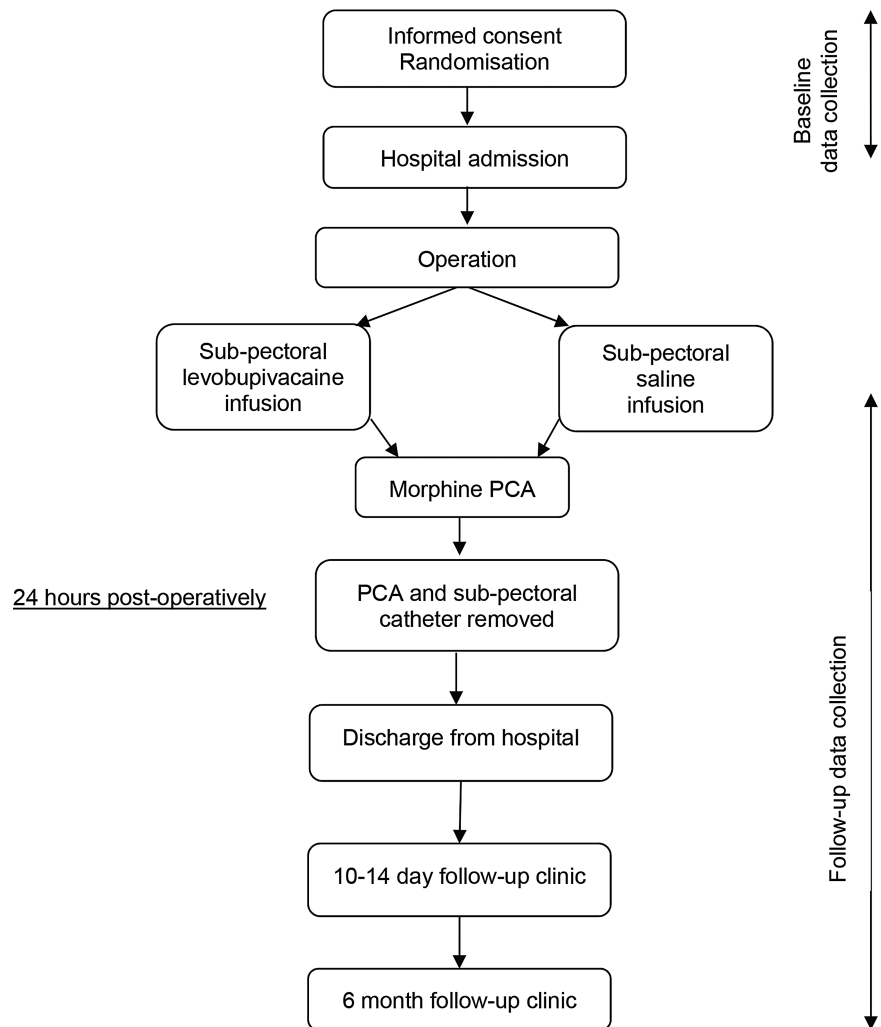
### Study procedures

Figure 1 shows the participant pathway through the study. Following informed consent, each participant is assigned a unique study number. Baseline data are normally collected at the preoperative assessment clinic, following consent. At this point the research nurse briefly explains use of the morphine PCA system and familiarises the participant with the Visual Analogue Scale (VAS) pain scoring system. Each VAS score is recorded on a separate page of a mini flipchart. The participant turns the page of the flipchart after an entry is made, so that the previous score is not visible for comparison when the next score is recorded.

### Interventions

The active investigational medicinal product is 0.25% levobupivacaine (chirocaine), an established local anaesthetic infusion agent, prepared as a 2.5 mg/mL solution and packaged by the manufacturer (Abbott) in ampoules for injection. The comparator solution, 0.9% sodium chloride, is sourced from standard NHS supplies at the participating sites. Active and comparator trial treatments are presented identically in infusion bags prepared by the local hospital pharmacy prior to the operation date and supplied on an individual patient basis according to treatment allocation. Bags are presented in heat-sealed outer packaging and labelled in accordance with current European Union regulatory requirements

**Figure 1** Trial schematic.



for clinical trials. Each bag is assigned a unique code number and a 7-day expiry date.

### Anaesthesia and surgery

Study participants receive a standardised anaesthetic protocol with respect to analgesic and antiemetic medication (see online supplementary appendix 1). Mastectomy is performed with/without sentinel lymph node sampling or clearance, as clinically indicated.

### Delivery of trial treatment

Trial treatment is delivered by means of an infusion catheter and device, supplied as a sterile prepacked kit and licensed for the delivery of local anaesthetic. At the end of the surgical procedure the surgeon inserts the infusion catheter percutaneously into the subpectoral plane under direct vision within the surgical field. After skin closure, a 20 mL bolus of active or comparator treatment is given via the catheter, which is then connected to the infusion device to provide an infusion of trial treatment at a continuous rate of 5 mL/h for 24 h. In the active treatment arm this equates to a 50 mg bolus of levobupivacaine followed by an infusion of 12.5 mg/h.

### Postoperative management and outcome assessment

In the recovery unit, postoperative pain is routinely managed with 2–3 mg aliquots of intravenous morphine to achieve a Verbal Rating Scale pain score of none–mild pain. All participants are provided with a PCA system set up to deliver intravenous morphine boluses of 1 mg with a 5-minute lock-out and no background infusion. Once all other routine recovery discharge criteria have been met, the patient is transferred to the ward. A baseline VAS pain score is recorded prior to transfer to the ward.

Participants are asked to complete VAS pain scores at rest every 4 h, with reminders from ward staff. The subpectoral infusion is discontinued after 24 h and the catheter removed, together with the PCA system. Outcome measures are assessed at 24 h and at routine follow-up visits, approximately 10–14 days and 6 months after the day of surgery (table 1).

### Primary outcome measures

The joint primary outcomes are (1) total morphine consumption (mg) in the first 24 h (defined as the 24 h following start of the subpectoral infusion), including all morphine given in the recovery unit and cumulative

**Table 1** Trial schedule

	Preoperative Baseline	Postoperative		
		24 h	14 days*	6 months
Screen/eligibility	x	OPERATION AND		
Consent	x	SET-UP OF TRIAL INFUSION		
BMI	x			
Concomitant medication	x		x	x
Oxford Shoulder Score (OSS)	x			x
Shoulder questions (from OSS)			x	
Shoulder goniometry	x	x	x	x
EQ-5D 5L	x		x	x
Randomisation	x			
VAS pain score		x	x	x
VRS pain score		x		
PCA attempts		x		
Total morphine consumption (oral/IV)		x		
Analgesia use		x	x	x
Adverse events		x	x	x
Brief Pain Inventory				x
Service use				x

\*Approximately 10–14 days post-operatively according to local practice.  
EQ-5D 5L, EuroQoL-5D 5L; VAS, Visual Analogue Scale; VRS, Verbal Rating Scale; PCA, patient-controlled analgesia.

PCA use as recorded by the PCA device and (2) total pain over the first 24 h, as defined by measurement of the area-under-the-curve of each participant's self-reported pain scores at rest, measured using a VAS. VAS pain scores are recorded in the recovery unit and then at 4 hourly intervals for the first 24 h. The VAS is presented as a 100 mm horizontal line with verbal anchors at each end of 'no pain' and 'worst pain possible'. The study participant selects and marks with a pen the point along the line that reflects their current pain perception. Periods of sleep are recorded retrospectively by the participant.

### Secondary outcome measures

Secondary outcome measures include the number of PCA attempts in the first 24 h following start of infusion; VAS pain scores at rest at 24 h, 14 days and 6 months after surgery; incidence of postoperative nausea and/or vomiting and use of supplemental analgesics and post-operative antiemetics in the first 24 h; self-reported analgesia use at 14 days and 6 months; duration of hospital stay; shoulder movement assessed by goniometry at 24 h, 14 days and 6 months following surgery; Brief Pain Inventory at 6 months; shoulder function (as measured by the validated<sup>31</sup>) at 6 months. Items from the are also assessed at the first follow-up visit in relation to the previous 7 days. Following the participant's discharge, the length of stay in hospital is recorded by the research nurse.

### Randomisation

Patients who consent to participate and fulfil the eligibility criteria are randomly allocated to receive either levobupivacaine or saline in a 1:1 ratio via a secure web-based

randomisation system. The allocation sequence is computer-generated by the UKCRC-registered Peninsula Clinical Trials Unit (CTU) in conjunction with an independent statistician, using a random permuted block design, with blocks of varying sizes. The block sizes will not be disclosed, to ensure concealment. As post-operative pain is expected to differ between patients who are having simple mastectomy, mastectomy with sentinel lymph node sampling or mastectomy with axillary node clearance, randomisation is stratified by planned surgical procedure and by recruiting centre. To ensure that the study team, including the study statistician, remain blind to participants' allocated study groups, randomisation is undertaken by the relevant hospital pharmacy department.

### Blinding and emergency unblinding

This is a double blind study and therefore participants, the surgical/anaesthetic team and the research team are unaware of each participant's allocated treatment group. To help assess the success of blinding, participants and the research nurse completing the follow-up assessments are asked to guess the participant's treatment assignment, at both the 14-day and 6-month follow-up visits.

In the event of a potential suspected unexpected serious adverse reaction, unblinding will be undertaken by the Sponsor in accordance with the regulatory requirements for safety reporting in Clinical Trials of Investigational Medicinal Products (CTIMPs). Unblinding may also be performed at the request of a senior clinician responsible for the care of a trial participant but such requests are likely to occur only in the case of an adverse clinical event and are expected to be rare. Any request to unblind treatment allocation for

clinical reasons will be made directly to the relevant hospital pharmacy and the treatment allocation will be reported to the relevant clinician according to an agreed procedure. The chief investigator and CTU trial manager will be kept informed of all instances of unblinding but remain blind to treatment allocations themselves wherever possible. The pharmacy and CTU will maintain a record of all requests for unblinding.

#### Data management

Data will be collected and stored in accordance with the Data Protection Act, 1998. Data will be recorded on study specific data collection forms and transferred to the CTU for double-data entry on to a password-protected database stored on a restricted access, secure server. Participants' anonymity will be maintained on all documents. Direct access to the trial data will be restricted to members of the research team and the CTU, with access granted to the Sponsor on request.

All participants will be encouraged to continue with follow-up as per protocol although they may withdraw from the study at any time without it affecting their care. Data collected prior to withdrawal will be included in the study analysis unless a participant specifically requests that their data are removed from the database.

#### Sample size

The study sample size was calculated to assess the joint aims of the effectiveness of a 24-hour continuous subpectoral local anaesthetic infusion on total morphine consumption and total pain over the 24-hour postsurgery period. Few studies have addressed the question of what reduction in total morphine use after breast surgery might be clinically important. A small number of studies have reported total morphine use after breast surgery, at varying end points.<sup>32–39</sup> Four have reported total morphine use at 24 h postsurgery; three of these were comparative studies. Two of these three studies based their sample size calculations on the same prior belief that the minimum clinically important difference was 10 mg (estimated SD of 10 mg, estimated mean 24-hour total morphine consumption of 40 mg).<sup>38–39</sup> Therefore, the minimum clinically important difference in 24 h total morphine consumption was set as 10 mg. These studies also showed actual SDs in 24 h postoperative total morphine consumption of 10–22 mg. To allow for the variability in the total morphine consumption being at the upper end of this range, the sample size calculation for total morphine consumption assumed a SD of 20 mg. To detect a difference of 10 mg between groups, with 80% power and at the 5% significance level, requires 65 participants per group.

Similarly, there is a lack of information on which to base a formal sample size calculation for pain as the (joint) primary outcome measure. With the sample size of 65 participants per group, there will be approximately 80% power to detect an effect size of around 0.5 SDs on the measure of pain. Such an effect size would be

considered as being of 'moderate' size.<sup>40</sup> From studies using a single VAS pain measure, it has been suggested that clinically meaningful differences are of the magnitude of 20–30 mm on a 100 mm VAS,<sup>41</sup> while a recent review reported that at the group level the difference in pain levels varied from 4 to 40 mm for acute pain.<sup>42</sup> Assuming the SD of the VAS is between 13<sup>43</sup>–44 and 26 mm,<sup>37–45</sup> this suggests that clinically meaningful effect sizes are of the order of at least 0.8 SDs. To detect a difference of around 0.8 SDs would need 26 patients per group, assuming a two-sided significance level of 5%, with 80% power. Therefore, the sample size of 65 participants per group will be large enough to detect clinically relevant differences between groups, in terms of pain.

The primary outcome measures are at 24 h with a minimal probability of drop out. However, enough participants will be recruited to attempt to ensure 65 participants per group are followed up at 6 months. As patients remain engaged with the breast service for clinical reasons, loss to follow-up is also expected to be low but there may be losses to the study because, for example, of the need for further surgery. Therefore, in order to achieve a study sample of 65 women per group at the 6-month follow-up, the aim is to recruit a total of 160 participants over a 2-year period, which allows for a loss to follow-up rate of just under 20%.

#### Statistical analyses

The primary analyses are all prespecified and a detailed statistical analysis plan will be completed and agreed by the Data Monitoring Committee (DMC) prior to start of analyses. Data will be reported and presented according to the CONSORT statement.<sup>46</sup> Ninety-five per cent CIs will be calculated and presented where possible. The trial statistician will be presented with a database by the CTU containing a group code for each participant but not identifying which group is which; only after final analysis will the individual groups be identified.

The primary statistical analysis will follow an intention-to-treat approach, with the intent-to-treat population defined as all trial participants who completed the baseline assessment and underwent surgery. A per protocol analysis may be undertaken as a sensitivity analysis. The analysis of adverse events will be presented on a per protocol basis.

The primary analysis will compare (1) total morphine consumption and (2) 24-h pain AUC at 24 h postsurgery between the two groups using an analysis of covariance, including the stratification factors as covariates, with suitable transformation of total morphine consumption and pain AUC considered as necessary. The estimates of the differences in mean total morphine consumption and mean pain AUC will be presented, together with a 95% CI for the difference. Secondary outcomes will be compared between groups in a similar way using analysis of covariance for continuous outcomes and logistic regression for binary outcomes such as incidence of postoperative nausea and/or vomiting and use of postoperative

antiemetics in the 24 h following surgery. Comparisons of interest will be presented with 95% CIs.

### Interim analysis

An interim analysis will be undertaken after the 14-day follow-up data have been collected for the first 80 participants recruited. Given the nature of the study a stringent criterion has been set for early termination of the trial on grounds of efficacy, namely  $p < 0.001$  for both the primary outcomes, else continuation of the trial being recommended. Other outcomes to be included in the interim analysis will be agreed with the DMC but are likely to include pain and vomiting, as well as 6-month outcomes data available at the time of the interim analysis. The interim analysis will not influence the final statistical analyses; given the single interim analysis and the stringent stopping criteria, any further adjustment is not considered to be necessary. Serious adverse events (SAEs) will be routinely reported to the DMC and discussed (by email/telephone) as considered necessary; they will be formally reviewed at the interim analysis within the context of any emerging evidence on efficacy.

### Missing data

The nature of missing data will be examined to consider appropriate approaches such as multiple imputation. Where assumptions are necessarily made, alternative assumptions will also be used to conduct additional analyses examining how sensitive the results are to the baseline assumptions. For the joint primary outcome of pain VAS, the AUC can be calculated from available VAS scores even if some are missing, by using linear interpolation; but if one or more observations are missing at the end of the 24-h period, the last observation recorded will be carried forward in the primary analysis.

### Economic evaluation

The study will include an economic evaluation from an NHS perspective. Following the National Institute for Health and Care Excellence (NICE) reference case, the primary outcome for the economic evaluation will be the incremental cost per quality-adjusted life-year (QALY) gained. The study will collect resource use data for the main drivers of the marginal cost. Unit costs will be assessed using standard NHS reference costs and prices. Health-related quality of life will be measured using the EuroQoL-5D (EQ5D)-5L data collected at baseline, 14 days and 6 months and valued using the interim 'crosswalk' value set.<sup>47</sup> QALYs will be estimated within trial by assuming a constant tariff value for days 0–14 and a straight line extrapolation between tariff scores at 14 days and 6 months.

The outcome of the economic evaluation will be the incremental cost-effectiveness ratio (ICER; the additional cost per QALY gained). Sampling variation for the ICER will be reported as the SD, estimated by bootstrapping and illustrated on the cost-effectiveness plane. Sensitivity analysis will be undertaken as appropriate

(depending on sampling variation and an analysis of relationships between QALY estimates and the other outcome measures) but it will include an analysis of the sensitivity of the estimated ICER to the functional form of the extrapolation between tariff scores at 14 days and 6 months.

### Ethics and dissemination

#### Ethical and safety considerations

Postoperatively, all participants are provided with a morphine PCA system in addition to the subpectoral infusion of trial treatment and therefore it is not considered that there are any ethical issues in using a placebo control. The recommended maximum single dose of levobupivacaine is 150 mg. The dose for postoperative pain management should not exceed 18.75 mg/h and the maximum recommended dose during a 24-h period is 400 mg. The maximum 24-h dose in this study is 350 mg which is therefore well within recognised safe limits.

#### Research governance

The protocol has been approved by the South West—Central Bristol Research Ethics Committee (REC reference 12/SW/0149) and follows the recent SPIRIT guidelines.<sup>48</sup> The Sponsor is responsible for judging the substantiality of any amendments to the study protocol. Important protocol modifications will be communicated to relevant parties by the Peninsula Clinical Trials Unit.

The study is conducted subject to the terms of a Clinical Trial Authorisation issued by the Medicines and Healthcare products Regulatory Agency (MHRA) and in compliance with the principles of the Declaration of Helsinki, ICH GCP, the Data Protection Act 1988 and the Medicines for Human Use (Clinical Trials) Regulations 2004 and subsequent amendments. The study has been adopted by the NIHR Clinical Research Network and has relevant local NHS Research and Development approvals. The study is sponsored by Royal Cornwall Hospitals NHS Trust and managed by the UKCRC-registered Peninsula Clinical Trials Unit at Plymouth University (Registration No.31).

A Trial Management Team meets regularly to monitor and discuss the progress of the trial and to address any issues that arise. A Trial Steering Committee (TSC), with an independent chair, meets approximately every 6–9 months to oversee the overall conduct of the trial. A Data Monitoring Committee (DMC), comprising two independent clinicians and one independent statistician, meets approximately every 9–12 months to monitor safety and ethics, including issues relating to attrition, overall data completeness and patient safety. The agreed role and responsibilities of both committees are set out in written charters and the DMC provides written recommendations to the TSC following each meeting. The CTU will conduct central and site monitoring in accordance with a risk-based monitoring plan and the study Sponsor may audit trial conduct as deemed appropriate.

### Timelines and dissemination plans

The study start was delayed due to amendments to the study design, described earlier. Research Ethics Committee approval was obtained in June 2012. Recruitment and training of staff involved in the study started in autumn 2012, and participant recruitment started at the first study site in December 2012. Participant recruitment is due to be completed by the end of 2014, with the final 6-month follow-up visits in early summer 2015. Statistical analyses will start once final data collection, monitoring and data cleaning is complete. The chief investigator will establish a writing committee comprising individuals who have made key contributions to study design and conduct and it is anticipated that the first publications will be ready for submission by early 2016. As well as the submission of research articles to appropriate peer-reviewed journals, research findings will be submitted for presentation at local, national and international scientific meetings including the European Society of Regional Anaesthesia annual scientific meeting.

The study team will prepare a plain English summary of the study results which will be sent to the study participants as soon as possible after the end of the trial. In addition, the final results of the study will be presented at meetings of the local breast cancer support groups.

### CONCLUSIONS

The lack of good quality evidence regarding the effectiveness of a continuous local anaesthetic infusion on postoperative pain following mastectomy indicates the need for well-designed clinical trials to investigate this subject. This study has been designed to investigate whether the use of a continuous local anaesthetic infusion in the subpectoral tissue plane can improve post-operative analgesia and quality of life for patients undergoing mastectomy, with or without axillary surgery.

This is the first study to assess the use of such a continuous infusion in the subpectoral plane, as well as the first study to assess the effects on postoperative shoulder function or the development of chronic pain and will therefore give a pragmatic answer to the question of whether continuous local anaesthetic infusion in the subpectoral tissue plane should be used in these patients.

#### Author affiliations

<sup>1</sup>Department of Anaesthesia, Royal Cornwall Hospital, Truro, UK

<sup>2</sup>Department of Surgery, Royal Cornwall Hospital, Truro, UK

<sup>3</sup>Peninsula Clinical Trials Unit, Plymouth University Peninsula Schools of Medicine and Dentistry, Plymouth, UK

<sup>4</sup>NIHR Research Design Service (South West), Truro, UK

<sup>5</sup>Centre for Biostatistics, Bioinformatics & Biomarkers, Plymouth University Peninsula Schools of Medicine and Dentistry, Plymouth, UK

**Contributors** IB adapted the subpectoral catheter technique and originally conceived the study. RL and IB developed the trial with methodological advice from SC and CP, specialist pain advice from KM and trial management advice from JV. SC is the trial statistician. JV is the trial manager. All authors helped to develop the study protocol to its final version.

**Funding** This paper summarises independent research funded by the National Institute for Health Research (NIHR) under its Research for Patient Benefit (RfPB) Programme (Grant Reference Number PB-PG-0610-22342). The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

**Competing interests** None.

**Ethics approval** South West England Research Ethics Committee.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Open Access** This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

### REFERENCES

1. Statistical Information Team, Cancer Research UK, 2010.
2. The NHS Information Centre. *National Mastectomy and Breast Reconstruction Audit 2011: A National Audit of the Provision and Outcomes of Mastectomy and Breast Reconstruction for Women in England*. Fourth Annual Report. 2011.
3. Health and Social Care Information Centre. Hospital Episode Statistics: main procedures and interventions 2012–2013. <http://www.hesonline.nhs.uk>
4. Skov J, Kroner K, Krebs B, *et al*. Pain and dysesthesias in the mastectomy scar. *Ugeskr Laeger* 1990;152:3081–4. Article in Danish.
5. Tasmuth T, von Smitten K, Hietanen P, *et al*. Pain and other symptoms after different treatment modalities of breast cancer. *Am Onc* 1995;6:453–9.
6. ON-Q Clinical Library. [http://www.iflo.com/clinical\\_library.php](http://www.iflo.com/clinical_library.php)
7. Macrae WA. Chronic post-surgical pain: 10 years on. *Br J Anaesth* 2008;101:77–86.
8. Macrae WA. Chronic pain after surgery. *Br J Anaesth* 2001;87:88–98.
9. Smith WC, Bourne D, Squair J, *et al*. A retrospective cohort study of post mastectomy pain syndrome. *Pain* 1999;83:91–5.
10. Chang SH, Mehta V, Langford RM. Acute and chronic pain following breast surgery. *Acute Pain* 2009;11:1–14.
11. Cheville AL, Tchou JB. Barriers to rehabilitation following surgery for primary breast cancer. *J Surg Oncol* 2007;95:409–18.
12. Fleissig A, Fallowfield LJ, Langridge CI, *et al*. Post-operative arm morbidity and quality of life. Results of the ALMANAC randomised trial comparing sentinel node biopsy with standard axillary treatment in the management of patients with early breast cancer. *Breast Cancer Res Treat* 2006;95:279–93.
13. McNeely ML, Campbell K, Ospina M, *et al*. Exercise interventions for upper limb dysfunction due to breast cancer treatment (Review). *Cochrane Libr* 2010;(6):CD005211.
14. Lauridsen MC, Overgaard M, Overgaard J, *et al*. Shoulder disability and late symptoms following surgery for early breast cancer. *Acta Oncol* 2008;47:569–75.
15. Pulido PA, Colwell CW, Hoenecke HR, *et al*. The efficacy of bupivacaine infiltration for pain management following orthopaedic knee surgery. *Orthop Nurs* 2002;21:31–8.
16. Wheatley GH, Rosenbaum DH, Paul MC, *et al*. Improved pain management outcomes with continuous infusion of local anaesthetic after thoracotomy. *J Thorac Cardiovasc Surg* 2005;130:464–8.
17. Sarhadi NS, Shaw Dunn J, Lee FD, *et al*. An anatomical study of the nerve supply of the breast, including the nipple and areola. *Br J Plast Surg* 1996;49:156–64.
18. Blanco R. The pecs block: a novel technique for providing analgesia after breast surgery. *Anaesthesia* 2011;66:847–8.
19. Perez MF, Miguel JG, Alfaro de la Torre P. A new approach to pectoralis block. *Anaesthesia* 2013;68:430.
20. Blanco R, Parras T, McDonnell JG, *et al*. Serratus plane block: a novel ultrasound-guided thoracic wall nerve block. *Anaesthesia* 2013;68:1107–13.
21. Blanco R, Fajardo M, Parras Maldonado T. Ultrasound description of Pecs II (modified Pecs I): a novel approach to breast surgery. *Rev Esp Anesthesiol Reanim* 2012. <http://dx.doi.org/10.1016/j.redar.2012.07.003>
22. Raghavendra GG, Sreenivasa RH, Ashok K, *et al*. Surgically placed wound catheters (SPWC) and local anaesthetic infusion in breast surgery: efficacy and safety analysis. *Breast Dis* 2011;33:1–8.



23. Talbot H, Huchison SP, Edbrooke DL, *et al.* Evaluation of a local anaesthetic regimen following mastectomy. *Anaesthesia* 2004;59:664–7.
24. Morrison JE, Jacobs VR. Reduction or elimination of post-operative pain medication after mastectomy through use of a temporarily placed local anaesthetic pump vs. control group. *Zentralblatt fur Gynakologie* 2003;123:17–22.
25. Baroody M, Tameo MN, Dabb RW. Efficacy of the pain pump catheter in immediate autologous breast reconstruction. *Plast Reconstr Surg* 2004;114:895–8.
26. Lu L, Fine NA. The efficacy of continuous local anesthetic infiltration in breast surgery: reduction mammoplasty and reconstruction. *J Plastic Reconstr Surg* 2005;115:1927–34.
27. Andraea MH, Andraea DA. Local anaesthetics and regional anaesthesia for preventing chronic pain after surgery (Review). *Cochrane Libr* 2012;(10):CD007105.
28. Bardsley H, Gristwood R, Baker H, *et al.* A comparison of the cardiovascular effects of levobupivacaine and *rac*-bupivacaine following intravenous administration to healthy volunteers. *Br J Clin Pharmacol* 1998;46:245–9.
29. Morrison SG, Dominguez JJ, Frascarolo P, *et al.* Cardiotoxic effects of levobupivacaine, bupivacaine and ropivacaine—An Experimental Study in Pentobarbital Anesthetized Swine. *Reg Anesth Pain Med* 1998;23:50.
30. Bay-Nielsen M, Klarskov B, Bech K, *et al.* Levobupivacaine vs bupivacaine as infiltration anaesthesia in inguinal herniorrhaphy. *Br J Anaesth* 1999;82:280–2.
31. Dawson J, Fitzpatrick R, Carr A. Questionnaire on the perceptions of patients about shoulder surgery. *J Bone Joint Surg Br* 1996;78-B:593–60.
32. Adam F, Libier M, Oszustowicz T, *et al.* Preoperative small-dose ketamine has no preemptive analgesic effect in patients undergoing total mastectomy. *Anesth Analg* 1999;89:444–7.
33. Bosek V, Cox CE. Comparison of analgesic effect of locally and systemically administered ketorolac in mastectomy patients. *Ann Surg Oncol* 1996;3:62–6.
34. Dirks J, Fredensborg BB, Christensen D, *et al.* A randomized study of the effects of single-dose gabapentin versus placebo on postoperative pain and morphine consumption after mastectomy. *Anesthesiology* 2002;97:560–4.
35. Grover VK, Mathew PJ, Yaddanapudi S, *et al.* A single dose of preoperative gabapentin for pain reduction and requirement of morphine after total mastectomy and axillary dissection: randomized placebo-controlled double-blind trial. *J Postgrad Med* 2009;55:257–60.
36. Ozalp G, Sarioglu R, Tuncel G, *et al.* Preoperative emotional states in patients with breast cancer and postoperative pain. *Acta Anaesthesiol Scand* 2003;47:26–9.
37. Pettersson N, Perbeck L, Hahn RG. Efficacy of subcutaneous and topical local anaesthesia for pain relief after resection of malignant breast tumours. *Eur J Surg* 2001;167:825–30.
38. Sidiropoulou T, Buonomo O, Fabbi E, *et al.* A prospective comparison of continuous wound infiltration with ropivacaine versus single-injection paravertebral block after modified radical mastectomy. *Anesth Analg* 2008;106:997–1001.
39. Talbot H, Hutchinson SP, Edbrooke DL, *et al.* Evaluation of a local anaesthesia regimen following mastectomy. *Anaesthesia* 2004;59:664–7.
40. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. NY: Academic Press, 1969.
41. Jensen MP, Chen C, Brugger AM. Interpretation of visual analog scale ratings and change scores: a Reanalysis of Two Clinical Trials of Postoperative Pain. *J Pain* 2003;4:407–14.
42. Ruyssen-Witrand A, Tubach F, Ravaud P. Systematic review reveals heterogeneity in definition of a clinically relevant difference in pain. *J Clin Epidemiol* 2011;64:463–70.
43. Johansson A, Kornfalt J, Nordin L, *et al.* Wound infiltration with ropivacaine and fentanyl: effects on postoperative pain and PONV after breast surgery. *J Clin Anesth* 2003;15:113–18.
44. McElwain J, Freir NM, Burlacu CL, *et al.* The feasibility of patient-controlled paravertebral analgesia for major breast cancer surgery: a Prospective, Randomized, Double-Blind Comparison of Two Regimens. *Anesth Analg* 2008;107:665–8.
45. Kim SY, Song JW, Park B, *et al.* Pregabalin reduces post-operative pain after mastectomy: a double-blind, randomized, placebo-controlled study. *Acta Anaesthesiol Scand* 2011;55:290–6.
46. Schulz KF, Altman DG, Moher D; for the CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. *BMJ* 2010;340:bmj.c332.
47. Devlin NJ, Krabbe PF. The development of new research methods for the valuation of EQ-5D-5L. *Eur J Health Econ* 2013;14:1–3
48. Chan AW, Tetzlaff Jm, Gotzsche PC, *et al.* SPIRIT 2013 explanation and elaboration: guidance for protocols of clinical trials. *BMJ* 2013;346:e7586.