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Creating and validating a Lateral Intercostal Artery Perforator And Other Local Chest Wall Flaps (LICAP) Stimulator

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Submitted in part fulfilment of the requirements for the Laidlaw Scholarship
November 2025

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Introduction

1.1 Background

Breast-conserving surgery (BCS) enables women with breast cancer to avoid mastectomy by combining safe tumour excision with adjuvant radiotherapy, thereby preserving the breast. Oncoplastic breast surgery (OBS) integrates oncological resection with techniques designed to optimise aesthetic and functional outcomes. OBS has demonstrated superior cosmetic and quality-of-life outcomes compared to traditional approaches, without compromising oncological safety or increasing morbidity (1). Consequently, OBS is now considered the standard of care for eligible patients (2), offering equivalent survival to mastectomy and significantly improved lifestyle and body image outcomes (3).

Oncoplastic techniques can be broadly categorised into volume-displacement procedures (e.g. therapeutic mammoplasty (TM)) and volume-replacement techniques such as chest wall perforator flaps (CWPF). These approaches have expanded the scope of breast conservation to tumours that previously necessitated mastectomy. CWPFs, including the lateral intercostal artery perforator (LICAP), anterior intercostal artery perforator (AICAP), and medial intercostal artery perforator (MICAP) flaps, were initially used in patients with small-to-medium-sized breasts and high tumour-to-breast volume ratios (4). With increasing expertise, indications have broadened to include centrally located tumours in small, non-ptotic breasts (5). Large multicentre studies such as PartBreCon further support CWPF as an effective technique with acceptable complication and margin re-excision rates (6).

Despite its benefits, training opportunities in CWPF are limited. UK breast surgeons currently train under the umbrella of general surgery, and recent Joint Committee on Surgical Training (JCST) curriculum updates (2021–2023) mandate completion of at least 25 autologous CWPFs for CCT in oncoplastic breast surgery (7). However, the international PERDITA study found that although 88% of surgeons regard CWPF skills as desirable, only one-third currently perform the procedure, with a median of just 10 cases per year (8). This highlights a significant mismatch between training requirements and available training opportunities.

1.2 Study Rationale

A dedicated CWPF surgical simulator could help bridge this training gap by enabling skill acquisition within a controlled, realistic environment outside the operating theatre. Simulation-based training supports competency development in complex surgical techniques and aligns with modern surgical education frameworks.

To maximise the educational impact of a CWPF simulator, a validated competency assessment tool (CAT) is also required. CATs assess performance across procedural steps and broader surgical domains, and have been successfully applied in related OBS procedures such as TM (9). A CWPF-specific CAT will allow structured feedback, objective performance evaluation, and standardised skill assessment.

Imperial College London's Department of Surgery and Cancer has significant experience in surgical simulation development (9-11), making it an ideal host institution for this work.

1.3 Study Stages

The LICAP-Sim Study comprises three stages:

(1) Simulator Development: Creation of a CWPF simulator replicating the surface and deep anatomy required for CWPF techniques, enabling realistic off-theatre training.

(2) Assessment Tool Development: Design and validation of a CWPF-specific CAT using established qualitative and consensus-building methodologies.

(3) Pilot Validation Study: Evaluation of the simulator and CAT across novice, intermediate, and expert surgeons.

Methodology

2.1 Methodology for stage 1 of the study

Stage 1: Development of a CWPF Surgical Simulator

The CWPF simulator will be adapted from an existing therapeutic mammoplasty model. Two experienced oncoplastic surgeons (Mr Daniel Leff (DL) and Dr Kate Harvey (KH)) will provide iterative expert guidance to ensure anatomical and procedural fidelity. The final simulator will aim to accurately replicate CWPF-appropriate anatomy and enable trainees to practise the procedure in a realistic environment independent of clinical theatres.

2.2 Methodology for stage 2 of the study

Stage 2: Development of a CWPF-Specific CAT

The CWPF-CAT will be developed using a modified Delphi approach *(Figure 1)*.

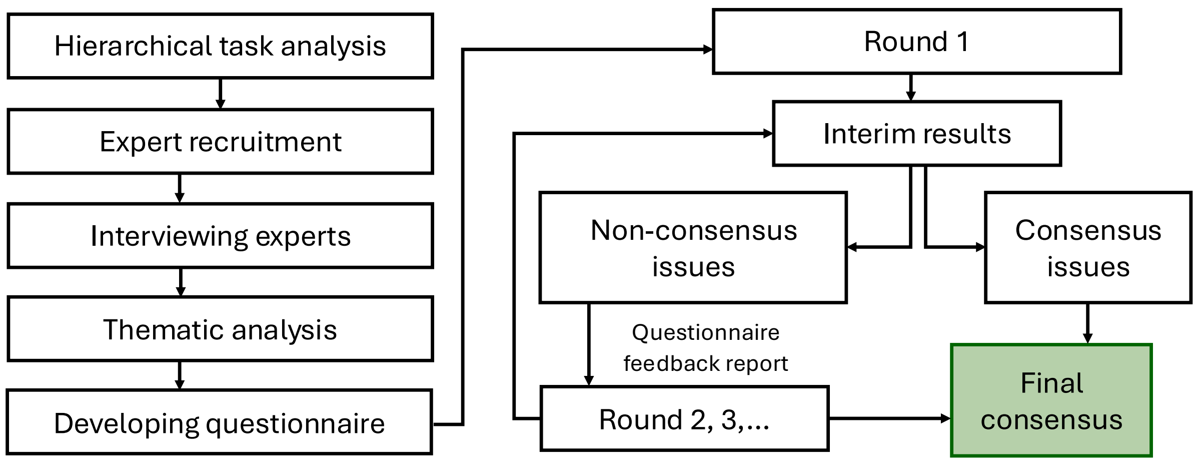

Figure 1: Modified Delphi process used to develop the competency assessment tool

The process includes:

1. Hierarchical Task Analysis

A hierarchical task analysis (HTA) will be undertaken by KH to map each step and technical variation of CWPF, informed by surgical experience and review of publicly available surgical videos.

2. Expert Recruitment

A purposive sample of 5–10 CWPF experts will be identified by DL and KH. Experts will be contacted via institutional channels. No recruitment will occur via NHS employment structures or premises.

3. Expert Interview

Semi-structured interviews (virtual or in-person) will explore CWPF steps, technical variations, and CAT domains (Exposure, Execution, Adverse Events, and End Product Quality). Audio recordings will be transcribed, pseudonymised, and securely stored.

4. Thematic Analysis and Developing Questionnaire

Transcripts and HTA outputs will undergo thematic analysis (Braun & Clarke) to generate a draft CAT framework.

5. Delphi Consensus Process

Experts will participate in iterative virtual Delphi rounds to refine and agree the CAT content. Consensus will be defined at 70%. If unresolved after three rounds, the research committee will adjudicate.

2.3 Methodology for stage 3 of the study

Stage 3. Pilot Validation Study

The CWPF simulator and CAT will be piloted and validated across three groups of surgical experience: Novice, Intermediate and Expert.

Novice surgeons in the CWPF technique are defined as core and higher surgical trainees with some experience in observing or assisting with CWPF experience. Novice surgeons will be recruited in person at the London School of Surgery Training Programme. This is a simulation-based training and assessment programme run by Imperial College London. They will be invited to perform a CWPF on the simulator as part of educational seminars.

Intermediate surgeons are defined as general surgery higher trainees with a declared interest in oncoplastic breast surgery and post CTT breast surgery fellows who are familiar with the technique, but do not routinely perform CWPF cases independently. They will be approached via existing trainee networks (DL and KH) and invited to perform a CWPF on the simulator at regional and national meetings.

Expert surgeons are defined as those who routinely perform CWPF procedures independently, it is anticipated they will mostly be consultant and associate specialist oncoplastic breast surgeons. They will be approached via academic emails and personal contacts (DL and KH). They will be invited to perform a CWPF case on the simulator at either at the Department of Surgical Technology at St Mary's Hospital, Praed St. or at national breast surgery meetings, such as the AGM hosted by the ABS (Association of Breast Surgeons) which happens twice per year. All participants will be recorded performing a case on the simulator and assessed using the novel CWPF-CAT.

Results

3.1 Development of the Competency Assessment Tool (CAT)

Seven consultant oncoplastic breast surgeons participated in the modified Delphi process for development of the CWPF Competency Assessment Tool (CAT). An initial hierarchical task analysis identified 12 key technical and cognitive domains relevant to CWPF performance. These domains informed the first-round Delphi questionnaire.

Following thematic refinement, statements and open-ended questions were generated to assess cognitive, technical, and judgement-related competencies across the preoperative, intraoperative, and postoperative phases of perforator-based breast reconstruction. Participants rated each statement on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) and provided qualitative responses to structured open-ended prompts.

Consensus was achieved on content and structure across all domains during the Delphi process, producing the final CWPF-CAT questionnaire *(Table 1)*.

Instructions

For each statement, please rate your agreement with the scale:

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

Where applicable, provide optional comments.

Section A: Preoperative Cognition & Planning

Statement	**1**	**2**	**3**	**4**	**5**
Preoperative mental rehearsal is essential before patient marking.	☐	☐	☐	☐	☐
Precise patient selection is a critical determinant of operative success.	☐	☐	☐	☐	☐
Surgeons should integrate imaging, lesion location, and laxity when planning markings.	☐	☐	☐	☐	☐
Anticipating intraoperative positioning during pre-op marking is important.	☐	☐	☐	☐	☐
Expert planning includes anticipating closure strategy at the time of marking.	☐	☐	☐	☐	☐
Open question: How do you structure your preoperative planning?	______				

Section B: Anatomical Mapping & Visual–Spatial Awareness

Statement	**1**	**2**	**3**	**4**	**5**
Expert performance requires translating 3D anatomy into accurate 2D skin markings.	☐	☐	☐	☐	☐
Markings should be reassessed in multiple patient positions.	☐	☐	☐	☐	☐
Volumetric estimation of tissue movement is a core preoperative skill.	☐	☐	☐	☐	☐
Novices struggle to account for contour, tension vectors, and closure direction.	☐	☐	☐	☐	☐
Open question: Describe your technical approach to multi-position marking.	______				

Table 1: CWPF Cognitive and Technical Assessment Questionnaire (Excerpt)

Conclusion

4.1 Conclusion

This project successfully developed a novel chest wall perforator flap (CWPF) surgical simulator and created a validated, procedure-specific competency assessment tool (CAT) to support training in perforator-based oncoplastic breast surgery. Through a structured modified Delphi process involving consultant-level experts, key cognitive, technical, and judgement-based domains were identified and refined to generate a targeted assessment framework.

The simulator offers a reproducible and accessible platform for technical skill acquisition in CWPF surgery, addressing the recognised challenge of limited operative exposure in current training pathways. Although the CAT has not yet been applied to trainee performance, the work completed in this study provides the foundation for structured assessment of simulator-based training in this emerging oncoplastic technique.

Overall, this study contributes a reproducible educational tool and an evidence-informed assessment instrument designed to enhance readiness for independent practice in CWPF surgery.

4.2 Significance

CWPF procedures represent an increasingly important component of contemporary oncoplastic practice, yet exposure during surgical training remains inconsistent. The development of this simulator and accompanying CAT provides a scalable and standardised solution to support trainees in developing local perforator flap competence.

By offering a safe, low-risk environment to practise flap design, perforator dissection, and inset planning, this simulator may help bridge the gap between curriculum requirements and available operative learning opportunities. In doing so, it has the potential to improve trainee confidence, technical proficiency, and preparedness for independent surgical practice in breast reconstruction.

4.3 Future Directions

Future work will focus on completing phase three of the study, applying the CAT to evaluate trainee performance on the simulator. Wider validation through multi-centre evaluation and larger participant cohorts will ensure robustness, reproducibility, and generalisability across UK oncoplastic training programmes.

Integration of the simulator into national oncoplastic curricula, alongside structured faculty training, will support consistent adoption. Additional development pathways include the incorporation of virtual reality (VR) or augmented reality (AR) modules to simulate flap perfusion and intraoperative decision-making.

Establishing performance benchmarks using expert-derived competency thresholds may enable its future use in readiness assessments for Certificate of Completion of Training (CCT) and standard-setting in advanced breast reconstruction training.

4.4 Acknowledgements

The author gratefully acknowledges the consultant oncoplastic breast surgeons who contributed to the Delphi consensus process, as well as the staff of the surgical skills laboratory and simulation centre for their assistance in model development and refinement. Special thanks are extended to Imperial College London Faculty of Medicine and partner NHS Trusts for their support throughout the project.

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