Identifying curriculum content for a cross-specialty robotic-assisted surgery training program

a Delphi study

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Title Page

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Running head: Cross-specialty curriculum for RAS

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ABSTRACT

Background: Robotic-assisted surgery is increasing and there is a need for a structured and evidence-based curriculum to learn basic robotic competencies. Relevant training tasks, eligible trainees, realistic learning goals, and suitable training methods must be identified. We sought to develop a common curriculum that can ensure basic competencies across specialties.

Methods: Two robotic surgeons from all departments in Denmark conducting robotic-assisted surgery within gynecology, urology, and gastro-intestinal surgery, were invited to participate in a three-round Delphi study to identify learning goals and rank them according to relevance for a basic curriculum. An additional survey was conducted after the Delphi rounds on what training methods were considered best for each learning goal and who (console surgeon/patient-side assistant) should master each learning goal.

Results: Fifty-six robotic surgeons participated and the response rates were 86%, 89%, and 77%, for rounds 1, 2 and 3, respectively. The Delphi study identified 40 potential learning goals, of which 29 were ranked as essential e.g. *Understand the link between arm placement and freedom of movement* or *Be able to perform emergency un-docking*. In the additional survey, the response rate was 70%. Twenty-two (55%) of the identified learning goals were found relevant for the patient-side assistant and twenty-four (60%) were linked to a specific suitable learning method with >75% agreement.

Conclusions: Our findings can help training centers plan their training programs concerning educational content and methods for training/learning. Furthermore, patient-side assistants should also receive basic skills training in robotic surgery.

Keywords: Cross-specialty, robotic surgery, curriculum development, education.

INTRODUCTION

Robotic-assisted surgery is increasingly being used in most surgical specialties and the leading producer of robotic systems reported a number of 1,229,000 conducted procedures worldwide using their systems in 2019 [1].

There is a learning curve for new surgeons as the handling of the instruments, visualization and haptic feedback in robotic surgery is different from conventional laparoscopy [2–4]. Furthermore, the inclusion of a robot to the team adds further complexity to surgery and increases demands on the operating team [5].

Surgical errors often occur due to lack of competence or communication breakdowns [6] and this also applies for robotic-assisted surgery [7]. Some errors are specific for robotic surgery and therefore additional education is important to ensure that robotic-assisted surgeries are performed safely [8].

An international multidisciplinary consensus group statement on robotic surgery recommended a structured training program for novices in robotic-assisted surgery [9].

Currently, the education offered to robotic surgeons varies in content and design [10–12] and the quality of training differs depending on the location and specialty [13]. The content of the training programs is often specialty-dependent and lacks a structured methodology. A full surgical curriculum should include relevant theoretical, technical, and non-technical skills.

Robotic-assisted surgery is widely used in gynecology, urology, and gastro-intestinal surgery and there are many common basic skills and competencies, e.g. knowledge of robotic equipment or emergency procedures. In a nationwide questionnaire among robotic surgeons from the three specialties in the Netherlands, the majority agreed on the need for a multidisciplinary basic training program for robotic surgery [14]. There is currently no cross-specialty consensus regarding the content or form of a common robotic curriculum.

Curriculum development is resource-efficient when overlaps and gaps of the learning goals are identified [15]. According to *Kern's approach to curriculum development* [16, 17], six steps should be included.

Where Kern's step 1 is problem identification and is described above, Kern's steps 5 and 6 are implementation and evaluation, these are often determined locally by the politics, funds, and support of each educational center.

This study aimed to identify who should master relevant learning goals in regard to their role in the surgical team (Kern's step 2). And to identify learning goals and establish consensus on the rank of relevance for basic competencies for robotic-assisted surgery across the three specialties: gynecology, urology, and gastro-intestinal surgery (Kern's step 3). And finally, to identify suitable learning methods for each identified learning goal (Kern's step 4).

METHODS

We used a three-rounded Delphi survey to identify and rank the importance of the learning goals. This method has previously been used to reach consensus on content for curricula in medical education [2, 18–21].

The Delphi method is used to systematically gather opinions and to rank these through an iterative process. In the first round, participants can suggest educational content, which then will be synthesized and rated in the second round. In the third round, the Delphi panelists are presented with the anonymized responses from the previous round and have the chance to re-evaluate their previous responses [22].

After the Delphi survey, we asked the Delphi participants which training methods should be used and who in the surgical team (console surgeon/patient-side assistant) should master each identified learning goal.

Selection of participants for the Delphi panel

Processing group:

A Delphi processing group consisting of seven members was formed. The composition of the group included experienced surgeons performing robotic-assisted surgery from each of the three above-mentioned specialties, and with geographically dispersed work locations representing the different regions of Denmark. The group also included surgeons with an interest or background in medical education research. The members were identified and invited based on these roles.

The Delphi panel:

All departments of gynecology, urology, and gastrointestinal surgery in Denmark performing robotic-assisted surgery were identified. Two robotic surgeons from each department were invited to participate in the survey, which evens out the possible differences in behavior and attitudes that may exist among departments. The participants were appointed either by the head of the department or by the regional representative from the processing group. In total, 56 robotic surgeons from 28 departments were invited to participate in the Delphi panel. The distribution of participants was: Gynecology n=18, Urology n=16, Gastro-intestinal surgery n=22.

Questionnaire design and distribution

The questionnaire was designed and distributed through the online survey software Surveyxact© (Rambøll Management Consulting, Aarhus, Denmark.) The questionnaire was pilot tested on surgeons who were not included in the Delphi panel to ensure an appropriate understanding of the questions.

All questionnaires were written in English and the participants had the opportunity to respond in English or Danish. The processing group then translated the Danish answers into English during the synthesis of learning goals. The Delphi participants had three weeks to answer each questionnaire except for the second Delphi round which had an extra week added due to national holidays. Weekly reminder e-mails were sent to participants who had not yet replied.

The Delphi Process

The Delphi participants had to provide written informed consent and information on their experience as robotic surgeons before they could participate in the first round of the survey.

Round 1:

In round 1, the Delphi panel was presented with an open-ended question: "*What content do you think should be included in a robotic-assisted surgery curriculum*." The participants had the opportunity to suggest educational content and add comments if they felt there was a need for elaboration.

The submissions from the first round were summarized in a single document, listed in random order for anonymizing purpose, and distributed to the processing group prior to the first process group meeting. At the meeting, duplicates were removed, understandings were discussed and resolved, and irrelevant or procedure-specific items were excluded. Thus synthetizing a list of proposed learning goals that were formulated in accordance with Bloom's taxonomy for curriculum development [23]. The identified learning goals were indexed in domains generated by the processing group.

Round 2:

In the second round, the synthesized list of learning goals was presented to the participants who were asked to rate them for relevance for a robotic-assisted surgery curriculum on a five-point Likert scale:

1 = not relevant, 2 = less relevant, 3 = relevant, 4 = very relevant, 5 = essential.

The participants were encouraged to comment and suggest new learning goals to each domain in case they considered the list to be incomplete.

In the processing of round 2, the new submissions of learning goals and comments were presented to the processing group after the same framework used to process round 1 and new learning goals were synthesized. The participants' rating data was analyzed and displayed as bar charts displaying the distribution of responses presented as percentages on the 1-5 Likert scale. None of the rated learning goals was excluded in the processing of round 2.

Round 3:

We presented the rating results as bar charts with the distribution of responses for each of the learning goals from round 2 for the participants. The participants rated the learning goals and could not comment or add new learning goals in this round. None of the rated learning goals were excluded in the processing of round 3.

Additional survey:

After the final Delphi round, we asked the participants who should master each learning goal: Console Surgeons, Patient-side assistants, or both. In addition, they were asked to choose suitable learning methods for each learning goal from a list (Table 1). The participants could select more than one learning method per learning goal.

A flowchart of the Delphi process is illustrated in Figure 1.

The responses of the participants were anonymous throughout the study.

Definition on consensus, ranking, and data analysis

The rank of learning goals was determined in regard to the strength of the agreement using the measures; median, interquartile range, and proportion of the panel responding 4 or 5 on the Likert scale in different combinations to evaluate the criteria of *essential, very relevant, relevant, or not* *relevant* (Table 2). These criteria have been used previously in a similar consensus study [24]. Data were analyzed using SPSS V.24. (IBM Inc., Armonk, New York, USA).

Ethical approval

The study was submitted to the Regional Ethical Committee of Southern Denmark, which found that ethical approval was not required (Journal No. 201920000-88).

RESULTS

The response rates were 86%, 89%, and 77% in the first, second, and third rounds, respectively. All 28 departments were represented in all three Delphi rounds. The distribution of responses according to specialty for each round is displayed in Table 3.

The median (range) years of experience of practicing robotic surgery among the participants who responded in the first round were 4 years (1-12 years).

In the first round, the participants supplied 227 item suggestions. After the removal of duplicates and understandings were resolved, 37 learning goals were synthesized and indexed in domains as listed in Table 4. In the second round, the participants supplied six new suggestions for learning goals and added 22 comments. After processing, three new learning goals were added and two learning goals were rephrased for clarification, resulting in a total of 40 learning goals. The rating results from rounds 2 and 3 are submitted as a table in supplementary materials.

In the final Delphi round the participants rated 35 of the 40 potential identified learning goals as relevant or higher, and five learning goals as *not relevant*. Six learning goals rated in round 2 changed their rank after re-rating in round 3. Twenty-nine of the learning goals were rated essential to be included in a curriculum. All the identified learning goals in the domain *technical skills* were rated essential and there was an overall tendency that technical skills were rated higher than learning goals labeled knowledge. One example is the goal: "*Be able to perform intra-abdominal entry technique"* which was rated essential while the learning goal "*Knowledge of physiology of pneumoperitoneum"* reached consensus as being *Not relevant.* Results from both rounds 2 and 3 are displayed in the supplementary materials and the final consensus results are shown in Table 5.

In the additional survey on training methods, 39 (70%) of the 56 participants responded. Twenty-seven departments were represented as one urology department did not respond (Table 3). For 24 of the learning goals, there was an agreement of >75% on a specific suitable learning/training method. In general, E-learning was rated high for the theoretical learning goals and virtual reality and animal models were rated high for the technical learning goals. There was >75% agreement on 22 (55%) learning goals to be trained by both the console surgeon and the patient-side assistant. In table 5, the responses are displayed as a proportion of the responding participants' voting for each learning goal.

DISCUSSION

We identified 35 relevant learning goals for basic competencies in robotic-assisted surgery across three specialties. We obtained a very high response rate compared with other studies [25, 26] as a higher number of items is normally associated with a lower response rate [27]. Additionally, we identified which training/learning methods robotic surgeons consider best for each of the competencies and whether the console surgeons, the patient-side assistants, or both should acquire the competencies. Our findings can work as the first blueprint for developing curricula for basic competencies in robotic-assisted surgery across specialties.

A surgical curriculum should cover both theoretical, technical, and non-technical skills [13]. We found that *E-learning* is preferred for the theoretical knowledge, *Virtual Reality* and *Animal models* for the technical skills training, and *Team Training* for the non-technical skills. This is in line with previously published single-specialty curricula [28, 29] stating that a curriculum must include various teaching methods depending on the learning goal.

There was a tendency that skills were rated more relevant than knowledge. The same was observed when Ismail et al. explored core skills for robotic first assistants in gynecology [30] and when Thellesen et al. explored curriculum content for Cardiotocography [25]. Another example is the item *Understand the aspects and benefits of the pre-procedural checks* which reached consensus as *Not relevant* despite its proven justification for surgical procedures in general [31]. Currently, many robotic surgeons have experience from conventional laparoscopy and open surgery and the Delphi participants may consider the learning goals focusing on knowledge as basic surgical competencies, which trainees should already be familiar with before commencing robotic-assisted surgery training. As the use of robotic-assisted surgery continues to grow and with work hour regulations there is a potential risk of trainees having less experience in conventional surgery skills when they are introduced to robotic surgery [32]. Hence, it is likely necessary to teach skills that used to be mastered before learning robotic-assisted surgery alongside specific robotic skills. Educational institutions should pay attention to this in the future.

In the domain *Non-technical skills*, five learning goals were identified and only two were rated essential. Non-technical skills often do not receive the same degree of interest and attention as technical skills [32]. Ahmed et al. describe the inclusion and importance of non-technical skills when establishing a standardized curriculum for robotic surgeons [33], whereas Ismail et al. did not identify any non-technical skills [30]. In a study including the entire surgical team, Al-Jundi et al. reported that 81% of the participants stated that non-technical skills are as important as technical skills in improving the surgical outcome [34]. The Delphi panel was composed of surgeons alone, and this may be one of the resons for the low attention to non-technical skills. One other explanation for the low attention to non-technical learning goals in our study could be that they are considered integrated into the identified technical learning goals [35]. The learning goal *Be able to perform emergency un-docking* which is technical but contains non-technical aspects e.g. decision-making, communication, leadership, and situational awareness is an example of this inter-connection. This is consistent with the findings of Raison et al. when identifying suitable components for the evaluation of non-technical skills in robotic surgery [36].

As an important measure of Kern's framework [16], we surveyed opinions on which learning goals were relevant for the console surgeons and the patient-side assistants, respectively. For 22 (55%) of the learning goals, at least 75% of participants thought they were relevant for the patient-side assistant as well as the console surgeon. The 75% agreement is a common definition of consensus [37]. In the domain *Technical skills*, the Delphi panel was divided; more than half of the panel voted four of the seven learning goals as only being relevant for the console surgeon, thus implying that the identified technical skills were not relevant for the assistant. In comparison, Ismail et al.

identified many technical skills of relevance for the first assistant only [30]. In the future, surgical trainees are more likely to be exposed to robotic surgery during their training [38] and the patient-side assistant in robotic surgery has more responsibility than an assistant during conventional surgery [39]. Further studies are needed to explore what educational content the patient-side assistant needs. Our findings indicate that patient-side assistants should be invited to participate in the basic skills part of a robotic-assisted surgery curriculum [32].

Educational strategies is step four in Kern's framework [16] and our study differs from the previous studies not only by exploring cross-specialty learning goals but also by establishing consensus on their rank of relevance and identifying which learning methods are suitable for each learning goal. By including three specialties, we identified common basic surgical non-technical and technical skill competencies. The level of agreement among the participants and the fact that the list of learning goals is similar to other single-specialty studies [30, 33, 40], support the concept of using the same basic curriculum for multiple specialties. The participants' experience in robotic surgery varied from one to 12 years. This allowed us to gather opinions from new and well-established robotic surgeons. Often Delphi panels consist of decision-makers or participants who are very experienced in their field [2, 12, 25]. However, we believe that the range of experience among participants is a strength as the focus of this study was identification of basic skills and junior robotic surgeons may have a different perception of the competencies required than senior surgeons. Including participants at different experience levels have been used in earlier studies [18, 41].

A possible limitation is that we only included robotic surgeons employed in Denmark. With reference to the mentioned differences among educational centers, we believe that our results can be applied internationally because the competencies required are the same.

We ranked our learning goals instead of reaching consensus on the final content for a future curriculum. There are regional differences in needs, resources, and educational traditions that must be considered when developing and implementing a curriculum. Our findings can act as a blueprint for the design of training programs for basic robotic competencies, as both relevance of the learning goals and preferred training methods can help design a curriculum. As an example, in the domain *technical skills*, the teaching method Live animals/animal models was rated highest for all learning goals. Using live animals for basic skills training is not accessible everywhere and virtual reality simulation also received a high rating and may be a viable alternative.

The learning goals identified as relevant in this study can be used to develop basic robotic surgery curricula. We explored opinions on suitable methods to master each learning goal, which can guide educational centers in implementing cross-specialty training programs. The majority of the learning goals identified for the console surgeons were found relevant for the patient-side assistants and basic skills training in robotic surgery for patient-side assistants should be considered.

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Data sharing statement:

The datasets used for this study are available from the corresponding author on reasonable request.

Disclosure statements:

Drs. Peter Hertz, Flemming Bjerrum, Kim Houlind, Pernille Tine Jensen, Mikkel Lønborg Friis, Jan Jepsen, Lars Bundgaard and Lars Konge have no conflicts of interest or financial ties to disclose.

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FIGURE LEGENDS:

Figure 1 - Flowchart of the Delphi process and additional survey.