A REALIST PROCESS EVALUATION OF ROBOT-ASSISTED SURGERY: INTEGRATION INTO ROUTINE PRACTICE AND IMPACTS ON COMMUNICATION, COLLABORATION, AND DECISION MAKING

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Scientific summary

Background

Robot-assisted surgery offers many potential benefits for patients. While an increasing number of NHS Trusts are purchasing da Vinci robots, there are reports that the technology is failing to be introduced into routine practice. In robot-assisted surgery, the surgeon is physically separated from the patient and the theatre team. The importance of effective communication and teamwork for patient safety in the operating theatre is well recognised but the impact of this change in spatial configuration on communication and teamwork has not been explored in previous evaluations of robot-assisted surgery, which typically focus on the role of the surgeon. The spatial configuration of the theatre team and technology in the operating theatre influences the gathering of information that is used to inform decision making but this is another area where the impact of robot-assisted surgery remains unexplored. Therefore, to ascertain how and under what circumstances robot-assisted surgery is effectively introduced into routine practice and how and under what circumstances robot-assisted surgery impacts communication, teamwork, and decision making, we undertook a process evaluation alongside ROLARR (RObotic versus LAparoscopic Resection for Rectal cancer), a randomised controlled trial comparing robot-assisted surgery and laparoscopic surgery for the curative treatment of rectal cancer.

Objectives

The study had the following research objectives:

1. To contribute to the interpretation and reporting of the results of ROLARR by investigating how variations in implementation of robot-assisted surgery, and the context in which it is implemented, impact on outcomes such as operation duration, conversion to open surgery, and complications;
2. To produce actionable guidance for healthcare organisations on factors likely to facilitate successful implementation and integration of robot-assisted surgery;
3. To produce actionable guidance for theatre teams on how to ensure effective communication and teamwork when undertaking robot-assisted surgery; and

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4. To provide data to inform the development of tools and technologies for robot-assisted surgery to better support teamwork and decision making.

Methods

Realist evaluation, which involves eliciting, testing, and refining stakeholders' theories of how an intervention works, provided an overall framework for the study. The study was organised into three Phases.

In Phase 1, a review of literature was undertaken to identify stakeholders' theories concerning how robot-assisted surgery becomes embedded into surgical practice and its impacts on communication, teamwork, and decision making in the operating theatre. These theories were refined and added to through interviews conducted across nine NHS Trusts that were using robot-assisted surgery for rectal cancer resection. A total of 44 interviews were conducted; participants included surgeons, anaesthetists, theatre nurses, operating department practitioners, and surgical trainees. Interviews were undertaken using the teacher-learner cycle, where the interviewees were invited to reflect on the theories from the review based on their experience of robot-assisted surgery and to describe how and in what ways those theories fitted with or differed from their experience. Interviews were audio recorded and transcribed verbatim. An iterative approach was taken to data collection and analysis so that emerging theories could be explored in subsequent interviews. Framework analysis was used to analyse the interview data, with codes focusing on capturing and tracking how the theories were expanded, supported, and refined.

At the beginning of Phase 2, the tentative theories emerging from Phase 1 were prioritised with input from clinical stakeholders to select four theories to take forward for testing. These theories were tested in a multi-site case study conducted across four NHS Trusts. Data was collected using multiple methods: the structured observation tool OTAS (Observational Teamwork Assessment for Surgery); video recordings of operations; ethnographic observation; interviews; and the Surgery Task Load Index (SURG-TLX) questionnaire which measures subjective workload associated with an operation. A total of 22 rectal cancer resections were observed,

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16 robot-assisted and six laparoscopic, representing 202 hours of data collection. Video data was collected across three case sites, for eight robot-assisted operations and one laparoscopic operation, providing 52 hours of recordings. Thirty brief post-operation interviews were undertaken with surgeons and members of the theatre team, along with four longer interviews with surgeons once the observations had been completed. Fifty-five questionnaires were completed. An iterative approach to data collection and analysis was taken, to enable ongoing testing and refinement of the theories and the gathering of further data in light of such revisions. As a first step in analysing the data, a series of matrix displays was produced, one for each theory. These provided a summary of the data for each operation that was relevant to the theory, drawing together data from the field notes, the post-operation interviews, OTAS, and the SURG-TLX questionnaire. This led to further analysis, including indexing of the field notes and interview transcripts, qualitative and quantitative analysis of the video data, and statistical analysis of the OTAS and SURG-TLX data, in order to answer specific questions related to the theories.

In Phase 3, interviews were conducted at the case sites with staff representing other surgical specialties, to assess the extent to which the results of Phase 2 were generalisable and to refine the resulting theories to reflect the experience of a broader range of surgical specialties. A total of 13 participants were interviewed, with experience in urology, gynaecology, and upper gastrointestinal surgery. Participants were surgeons, theatre nurses, operating department practitioners, and surgical trainees. Interviews were audio recorded and transcribed verbatim. An iterative approach was taken to data collection and analysis, with framework analysis being used as the method of analysis.

Findings

In Phase 1, the literature review identified 228 relevant papers, consisting of 22 systematic reviews of colorectal robot-assisted surgery, 94 other systematic reviews of robot-assisted surgery, 37 individual studies of colorectal robot-assisted surgery, and 75 editorials or commentaries, along with 34 websites. There was considerable repetition of the theories across sources. The majority of the papers were authored

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by surgeons with a clinical interest in robot-assisted surgery. The review revealed the series of decisions that are made in the process of introducing robot-assisted surgery and the challenges that need to be overcome if robot-assisted surgery is to be successfully integrated into routine practice. A number of theories emerged from the review regarding how and in what contexts robot-assisted surgery becomes integrated into routine practice, including how and in what contexts the strategies of having a dedicated team and a dedicated operating theatre help to overcome the challenge associated with robot-assisted surgery of increased operation duration. The review identified less literature concerned with the impact of robot-assisted surgery on communication and teamwork in the operating theatre. However, the findings of the review suggested that robot-assisted surgery can hinder communication, due to the physical separation of the surgeon from the theatre team, which makes it harder for the team to hear the surgeon's requests. The review suggested that robot-assisted surgery can both support and impede decision making by changing the team's situation awareness, reducing the tactile information available to the surgeon, increasing the surgeon's sense of immersion when at the console, and reducing surgeons' stress through the ergonomic benefits of the robotic console.

The Phase 1 interviews explored the introduction of robot-assisted surgery into the NHS. Findings suggested it was a surgeon-led process but was dependent on support at different levels of the organisation. There was also significant variation across sites in the training provided to members of the theatre team. The interviews led to a refinement of the literature-based theories and the generation of additional theories, reflecting the experience of a broader range of operating theatre personnel. In relation to the implementation of robot-assisted surgery, the interviews suggested whole team training, handpicked teams, and manufacturer support were all contextual factors that influenced the integration of robot-assisted surgery into routine practice. Greater understanding of the impact of robot-assisted surgery on communication and teamwork was obtained and theories emerged regarding how and in what contexts particular strategies used by theatre teams, such as explicit communication, providing a commentary, and working with an experienced first

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assistant, work to overcome the challenges of communication and teamwork introduced by robot-assisted surgery. Further insight was provided into the contexts in which different resources provided and taken away by robot-assisted surgery impact decision making in the operating theatre.

In Phase 2, analysis of the empirical data led to refinement of the four theories that had been selected for testing. We found that working with an experienced first assistant supported teamwork in robot-assisted surgery but experience of the procedure was not sufficient for competence in robot-assisted surgery. Scrub practitioners played an important role in supporting first assistants who lacked experience in robot-assisted surgery. Robot-assisted surgery required more explicit communication than open and laparoscopic surgery, with surgeons undertaking additional work to secure the attention of the first assistant and scrub practitioner prior to issuing a request. Theatre team members also needed to provide oral responses to the surgeon's requests to confirm that work will be done and make apparent any challenges in completing the request. Robot-assisted surgery can result in reduced distraction and increased concentration for the surgeon, compared to open and laparoscopic surgery, but only when supported by an experienced first assistant or an experienced scrub practitioner. There was limited impact on the surgeon's situation awareness of the wider operating theatre due to their position in the console but they do experience challenges in maintaining awareness of the position of robotic instruments within the surgical site.

The Phase 3 interviews revealed the theories resulting from the multi-site case study to be generally applicable to other surgical specialties that undertake robot-assisted surgery. However, the interviews also identified other contextual factors to be incorporated into the theories. For the experienced first assistant, their ability to provide support without prompting will be affected by the extent to which the steps of the operation are routinised, the extent to which patient factors affect the level of support required, and the frequency with which they participate in robot-assisted operations. Maintaining awareness of the position of robotic instruments within the

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surgical site is less of a concern in those surgical specialties such as urology where they are working in a more confined space.

Conclusion

Implications for practice:

Our research suggests that, to support the integration of robot-assisted surgery into routine practice, healthcare organisations may find it useful to:

- Engage staff at different levels of the organisation: While board level support is likely to be essential for the introduction of robot-assisted surgery, it is also important to engage team leaders, as they can assist in creating conditions that accommodate the introduction of robot-assisted surgery, such as organising training and ensuring the right skill mix is available. Engagement of those surgeons who will not be using the robot is also important; if surgeons perceive that the introduction of robot-assisted surgery is supported by their colleagues, they are likely to be more willing to undertake an operation with robot-assistance despite the initial longer operation duration.
- Handpick a dedicated robotic team: While unlikely to be feasible as a long-term strategy, a handpicked dedicated team can increase the speed with which experience is built up, increasing confidence and efficiency. However, care should be taken not to alienate those who are not part of that initial team.
- Ensure the team undertake training together: This is beneficial in terms of understanding the impact of robot-assisted surgery on each other's roles, supporting teamwork. It can work to increase trust in each other's knowledge so that the surgeon feels more confident in the team's ability to support him/her.
- Establish a suitably sized dedicated theatre: By having a suitably sized operating theatre, operation duration is reduced as staff are able to move quickly and the risk of de-sterilisation is reduced. A dedicated operating theatre reduces the time to set up the robot and speeds up turnover to the next case.

A strategy is also needed for training of the theatre team beyond the initial team and, when planning rotas, it is necessary to consider the skill mix of the team.

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Our research suggests, to ensure effective communication and teamwork when undertaking robot-assisted surgery, it is beneficial for surgeons to:

- Encourage the theatre team to communicate both actions and concerns: This helps theatre team members feel comfortable to speak up, leading to improved coordination and increased situation awareness for the surgeon. This strategy is more likely to be effective when there is a positive relationship between the theatre team and the surgeon.
- Secure the attention of the first assistant before issuing a request, particularly after a period without communication: This supports the first assistant to hear the message, leading to improved coordination. This strategy is more likely to be effective if the first assistant is already engaged in the operation.
- Acknowledge the role of the scrub practitioner in supporting an inexperienced first assistant, so as to increase the first assistant's willingness to accept that support. Where the scrub practitioner is experienced, this increases the likelihood that actions are performed correctly.

Our research suggests it is beneficial for the theatre team to:

- Provide an oral response to the surgeon's requests. This reassures the surgeon that the request will be completed and makes them aware of any challenges in doing this. This strategy requires that team members communicate loudly and clearly.
- Monitor both the screen and the movement of the robotic arms. This enables the team to notice when the robotic arms are clashing and alert the surgeon, increasing the surgeon's situation awareness. More experienced team members will be aware of the need to move their attention between the screen and the robotic arms.

Implications for research:

Future research should include:

1. Exploration of other areas of surgery where technology leads to the separation of the surgeon from the rest of the team, either physically or perceptually, and the transferability of guidance for effective communication and teamwork to those

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settings. Possible areas are the use of microscopes in plastic and reconstructive surgery, ophthalmic surgery, and neurosurgery.

2. Investigation of the potential for realist evaluation to contribute to the design of randomised controlled trials and associated process evaluations through inclusion of realist methods in feasibility and pilot studies.
3. Assessment of the feasibility of using routinely collected data, such as that contained within the NHS National Reporting and Learning System and national registries, to understand the impact of robot-assisted surgery on rare endpoints associated with patient safety.
4. Development and evaluation of methods for whole team training.
5. Experimental evaluation, *in situ*, of the impact of different physical configurations of the robotic console and team members on communication and teamwork in the operating theatre, with quantitative and qualitative data collection and analysis.

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