Original Article

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# Technical problems during laparoscopy: a systematic method of troubleshooting for surgeons

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**Abstract**

**Background:** Laparoscopic surgery has progressed rapidly since the early 1990s. For some surgical operations, it has become the standard of care to the extent where open surgery is sometimes looked down upon by some surgical colleagues as well as by patients.
**Current status:** Despite this widespread adoption and acceptance, many surgeons struggle to understand how the laparoscopy stacks work despite having the skills to perform the operation. Most hospitals rely on operating theatre assistants to troubleshoot in the event of problems. This could be potentially unsafe for patients if laparoscopic vision or pneumoperitoneum is lost at a critical point of the operation.
**Discussion:** There are a number of approaches that have been published for troubleshooting laparoscopy stack. We explore and discuss some of them along with their advantages and disadvantages and how they relate to our methodology and approach. As a product of the discussion, we suggest a systematic way forward to troubleshooting laparoscopic tower equipment problems.
**Conclusion:** The technical knowledge of surgeons and trainees varies widely in the area of laparoscopy-related troubleshooting. This systematic, practical algorithm would help and guide all surgeons to adopt a uniform approach, thereby improving patient safety.

**Keywords:** image quality; insufflation; laparoscopy; pneumoperitoneum; troubleshooting.

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**Kor Woi Tiang:** Department of Surgery, Logan Hospital, Brisbane, Queensland, Australia

## Introduction

The core equipment in laparoscopic surgery has largely remained unchanged since the 1990s and this includes the scope, the laparoscopic tower or stack and the connection cables [1]. However, as the laparoscopic procedures undergo new innovations and become more complex, equipment continue to evolve to keep up with the latest surgical techniques as well as technological advancement [2]. With this, the maintenance and troubleshooting of laparoscopic equipment in the event of technical problems also become challenging. To optimise patient safety, theatre staff including surgeons need to have a basic understanding and knowledge of laparoscopic equipment [3, 4]. Currently, many surgical training programmes do not seem to have dedicated curricula addressing this issue among surgical trainees. Furthermore, different companies that manufacture the same type of surgical equipment may have a wide variety of modifications [5].

## Current status

Laparoscopy as a technique is common in general surgery, with aspiring trainees being exposed to the various aspects of laparoscopy even before they enter training. So, what is the current understanding and skill set of trainees regarding the troubleshooting of laparoscopic equipment, including the laparoscopic tower? Many of these surgical trainees are competent in basic laparoscopic skills before application for training. In fact, it is a requirement in many countries for prospective applicants to training programme to have that basic knowledge of laparoscopy [6]. This implies that prospective and current surgical trainees have good understanding of the principles of basic laparoscopy. However, the question remains: does this translate to good understanding and troubleshooting technique among trainees?

There are various laparoscopic skill courses that are conducted by training bodies. The Royal Australian College of Surgeons (RACS) conducts Australian and New Zealand Surgical Skills Education and Training (ASSET), where trainees are taught the basics of laparoscopic skills [7, 8]. This is equivalent to the Basic Surgical Skills Course (BSS) in England and the Fundamentals of Laparoscopic Skills (FLS) in the United States. These courses are conducted over 2–3 days. The half-day session that addresses laparoscopy on this course is entitled "Principles and Practice of Rigid Endoscopy". The objective, as stated in its curriculum, is to ensure that the candidate "displays competency in a variety of basic practical skills relating to different endoscopic environments and the mechanics of instrumentation". During this course, candidates are introduced to various elements of laparoscopy, such as camera, scope, fibre optic cable, light source, gas connection and operations of the basic mechanics, and connections and operations of these elements. Candidates are then guided toward performing a number of simple laparoscopic tasks and practicing them. However, they are not taught methods regarding troubleshooting if any issues arise, except for checking connections and attempting to obtain a clearer image by adjusting settings on the camera head itself. In addition, the FLS course covers elements such as operating room setup, ergonomics, general use of laparoscopic instruments and equipment, safety consideration using the laparoscopic stack, laparoscopic training box and virtual reality trainers [9]. The breadth and depth of the curriculum required to teach laparoscopic equipment troubleshooting techniques are limited by time constraints.

## Approach to troubleshooting

The commonest source of problems when having trouble with laparoscopy equipment seem to be the scope, camera

**Table 1:** Approach to laparoscopy troubleshooting: insufflation.

| Issues | Possible causes | Solutions |
|---|---|---|
| Low or no insufflation pressure | Issues related to laparoscopic stack | |
| | – Gas tubing not connected to the stack | – Connect gas tubing to the stack |
| | – $CO_2$ tank empty or running low on volume | – Change gas tank |
| | – Gas flow rate or pressure at low setting | – Increase flow rate or pressure |
| | – Failure in the gas pressure regulation electronic | – (Even after gas flow and pressure is increased) Send unit for repair/checking by company technician after replacing |
| | Port or gas tubing-related issues | |
| | – Gas valve at the port not open | – Open the gas valve completely |
| | – Leak at the port due to improper connection with the gas tubing | – Secure the gas tubing properly to the gas valve at the port |
| | – Leak around the port | – Inflate the balloon if it is a balloon tip port/ close the skin or fascia around the port |
| | – Leak in the sealing cap of the port | – Replace the port |
| | – Open gas valve at the ports not connected to gas tubing | – Close the gas valve |
| | – Excessive pressure at the smoke evacuator | – Reduce the pressure or remove smoke evacuator |
| | – Occlusion/kink in the gas tubing OR | – Inspect the full length of the tubing and remove/correct occlusion |
| | – Cracked/damaged gas tubing | – Replace gas tubing |
| | Intraabdominal issues | |
| | – Excessive suctioning | – Use lower suction pressure and allow time to reinflate |
| | – Morbidly obese patient | – Need higher insufflation pressure |
| High or excessive insufflation pressure | Issues related to laparoscopic stack | |
| | – Gas pressure at low setting | – Increase pressure |
| | Port or gas tubing-related issues | |
| | – Port tip in the preperitoneal space | – Reposition the port tip into the peritoneal cavity |
| | – Closed gas valve at the port connected to gas tubing | – Open gas valve |
| | Intraabdominal issues | |
| | – Patient coughing/straining probably due to relaxant wearing off | – Request anaesthetist for muscle relaxation to be given to the patient |

head, light cable, light source, insufflation tube and gas insufflator [10]. There are a number of ways that problems could be addressed. A large proportion of the problems are due to user error. Different companies producing slightly different types of laparoscopic equipment, which is continuously evolving, adds another element of difficulty to the process of troubleshooting [5].

Verdaasdonk et al. [11] suggested that any approach to troubleshooting laparoscopic equipment challenges should be systematic and standardised and incorporate a form of checklist. They showed a 53% decrease in the adverse incidents while using such a systematic approach. The usage of checklist taking into account the fact that there are different types of laparoscopic stack

**Table 2:** Approach to laparoscopy troubleshooting: lighting and picture quality.

| Issues | Possible causes | Solutions |
|---|---|---|
| No picture | Issues related to laparoscopic stack | |
| | – Power not turned on | – Turn on the power |
| | – Cable between the monitor and the image producer or between the camera and the image producer loose | – Check and rectify the cable connections (various cables and connections exist as detailed above) |
| | – Light switch on the light source on "stand by" | – Take switch off "stand by" |
| | – Contrast/brightness set at lowest | – Set contrast/brightness correctly (can also be done with controls located on the camera head) |
| | – Xenon lamp burned out | – Send unit for repair/checking by company technician for lamp to be changed and replace the laparoscopic stack for the operation to continue |
| | – Sudden loss of light source | – It is due to either lamp being burnt out or light cable connections coming off loose. Rectify as mentioned above in those sections |
| | Issues relation to leads and laparoscope | |
| | – Loose connection between stack and leads or between leads and laparoscope | – Check and rectify the cable connections |
| Poor image quality | – Light too bright | – Decrease lighting at the light source/camera head |
| | – Too little light | – Increase lighting at the light source/camera head |
| | | – Check and rectify light lead connections with stack and camera head |
| | | – Send unit for repair/checking by company technician for lamp to be changed and replace the unit |
| | – Blurring/foggy | – Correct focus |
| | | – Clean the lens |
| | | – Wait for even gas distribution in the abdominal cavity and then introduce the scope allowing the laparoscope to adjust to varied temperature inside the body (intraabdominal) |
| | | – Dip scope in hot water/scope warmer |
| | | – Use thermoflator (warms delivered gas) |
| | | – Consider connecting gas tubing and smoke evacuator to the port that is not used by the laparoscope |
| | | – Use flow shield (available only for 5 mm ports) |
| | | – If heating element indicator light is ON, on the gas insufflator (some units can warm the gas supplied), send unit for repair/checking by company technician for lamp to be changed and replace the unit |
| | – Distortion/grainy | – Clean the connection between laparoscope and camera head for moisture |
| | | – Check for calcium build-up at the end of the scope (needs polishing with aluminium oxide) send unit for repair/checking by company technician/polishing by CSD |
| | – Flickering | – Check for cracked lens/camera head and replace |
| | | – Check for damaged light lead or camera lead and replace |
| | | – Clean the connection between laparoscope and camera head for moisture |
| | | – Check connecting cables between the image enhancement system and monitor for loose connections and cracks and rectify or replace unit |

and adjuncts has its own challenges, and one may need different checklists for different manufacturers.

Mees et al. [10] from Adelaide proposed an approach represented in the form of a flow diagram and followed a series of checklists. Their approach was to start with the monitor and work the way toward various leads and connections and then to the camera head and scope itself. Their study, however, specifically addressed poor image quality and how to solve those issues. It did not address issues related to gas insufflation.

Tichansky et al. [12] suggested a method where the whole laparoscopic equipment and its various adjuncts were divided into three groups, and problems associated with each group were addressed individually. They were (a) the laparoscopic stack that included the monitor, image enhancement system, gas insufflator (thermoflator) and light source; (b) leads that included fibre optic cable for light transmission, camera lead connected to the camera head, and the gas insufflation tube; and (c) the laparoscope itself. The image enhancement system is in turn connected to the monitor (up to two monitors could be connected), image link modules (up to three), light source, and documentation system (keyboard, printer and screen). The image enhancement system is connected to the monitor with visual interface cables. The most commonly used interface cables (digital) are digital visual interface (DVI) and/or serial digital interface (SDI).

It seems logical to group the equipment into categories and try to address the issues separately from each component. However, all these groups of equipment are interconnected and they work in unison and harmony to produce a clear picture. At times the issue may lie with part of the laparoscopic equipment that belongs to two different groups and so cannot be dealt with in isolation. Furthermore, the issue may lie with the patient and the effect of anaesthetic agents on the patient.

We suggest a method of troubleshooting laparoscopic tower problems by categorising them into either image quality problems or insufflation problems. The rationale behind this approach is that, when an issue arises, a surgeon relates that to an outcome that he can visualise. Image and lighting are intricately related, so we consider them a single entity for the purposes of problem solving. We have developed a chart we recommend to be used as a problem-solving chart in operating theatres (Tables 1 and 2).

## Conclusion

Laparoscopy as a surgical technique has continued to grow. However, surgeons, trainees and aspiring junior doctors have a varying degree technical knowledge of how the laparoscopy stack works. The current surgical training curriculum lacks specific components to address this knowledge gap. As this can potentially cause patient harm, we recommend the adoption of a uniform, logical and practical method that addresses this potential lack of knowledge and aid troubleshooting in a timely manner within the operating theatre.

**Author Statement**

Research funding: Authors state no funding involved. Conflict of interest: Authors state no conflict of interest. Informed consent: Informed consent is not applicable. Ethical approval: The conducted research is not related to either human or animals use.

**Author Contributions**

Manjunath Siddaiah-Subramanya: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Supervision; Visualization; Writing – original draft; Writing – review and editing. Masimba Nyandowe: Formal analysis; Investigation; Resources; Visualization; Writing – review and editing. Kor Woi Tiang: Data curation; Investigation; Resources; Software; Visualization; Writing – review and editing.

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**Supplemental Material:** The article (https://doi.org/10.1515/iss-2017-0031) offers reviewer assessments as supplementary material.

**Reviewer Assessment**

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## Reviewers' Comments to Original Submission

### Reviewer 1: Thomas Carus

Jul 03, 2017

| | |
|---|---|
| **Reviewer Recommendation Term:** | Accept with Minor Revision |
| **Overall Reviewer Manuscript Rating:** | 70 |

| **Custom Review Questions** | **Response** |
|---|---|
| Is the subject area appropriate for you? | 5 - High/Yes |
| Does the title clearly reflect the paper's content? | 4 |
| Does the abstract clearly reflect the paper's content? | 4 |
| Do the keywords clearly reflect the paper's content? | 4 |
| Does the introduction present the problem clearly? | 4 |
| Are the results/conclusions justified? | 4 |
| How comprehensive and up-to-date is the subject matter presented? | 4 |
| How adequate is the data presentation? | N/A |
| Are units and terminology used correctly? | 4 |
| Is the number of cases adequate? | N/A |
| Are the experimental methods/clinical studies adequate? | N/A |
| Is the length appropriate in relation to the content? | 4 |
| Does the reader get new insights from the article? | 3 |
| Please rate the practical significance. | 3 |
| Please rate the accuracy of methods. | N/A |
| Please rate the statistical evaluation and quality control. | N/A |
| Please rate the appropriateness of the figures and tables. | 3 |
| Please rate the appropriateness of the references. | 3 |
| Please evaluate the writing style and use of language. | 4 |
| Please judge the overall scientific quality of the manuscript. | 2 |
| Are you willing to review the revision of this manuscript? | Yes |

**Comments to Authors:**
It is a very important topic for all laparoscopic surgeons.
Some points are missing, e.g. what to do light source break down during the operation? Always check the life cycle of the light bulb before beginning the operation. It is almost impossible to change the bulb during the operation (very hot!), so there should be an extra light source.
The mentioned courses are very important. But normally every surgeons gets an instruction session before using the instruments or other technical devices. During these sessions, all kinds of possible problems are discussed to train the surgeon before the surgery. Therefore I see no real "danger" for patients, when surgeons didn't go to special courses or use strict algorithms. They should not learn by doing and have to be instructed, which can be done by several ways.
I don't agree the conclusion that "... surgeons, trainees and aspiring junior doctors have a deficiency in the technical knowledge...". These surgeons should not perform any laparoscopic operation before getting this knowledge. In Germany, surgeons have a device certificate for each device they use intraoperatively and are not allowed to use them without instruction.
These points should be mentioned in the manuscript.
Are there some data showing higher safety or less complications using e.g. a "problem-solving chart in operation theaters"?

## Reviewer 2: Ferdinand Köckerling

Jul 30, 2017

| | |
|---|---|
| **Reviewer Recommendation Term:** | Accept |
| **Overall Reviewer Manuscript Rating:** | 60 |

| **Custom Review Questions** | **Response** |
|---|---|
| Is the subject area appropriate for you? | 4 |
| Does the title clearly reflect the paper's content? | 4 |
| Does the abstract clearly reflect the paper's content? | 4 |
| Do the keywords clearly reflect the paper's content? | 4 |
| Does the introduction present the problem clearly? | 4 |
| Are the results/conclusions justified? | 4 |
| How comprehensive and up-to-date is the subject matter presented? | 4 |
| How adequate is the data presentation? | 4 |
| Are units and terminology used correctly? | 4 |
| Is the number of cases adequate? | N/A |
| Are the experimental methods/clinical studies adequate? | N/A |
| Is the length appropriate in relation to the content? | 4 |
| Does the reader get new insights from the article? | 3 |
| Please rate the practical significance. | 4 |
| Please rate the accuracy of methods. | N/A |
| Please rate the statistical evaluation and quality control. | N/A |
| Please rate the appropriateness of the figures and tables. | 4 |
| Please rate the appropriateness of the references. | 4 |
| Please evaluate the writing style and use of language. | 4 |
| Please judge the overall scientific quality of the manuscript. | 3 |
| Are you willing to review the revision of this manuscript? | Yes |

**Comments to Authors:**
The authors have developed a helpful checklist for the surgeon to overcome technical problems with the laparoscopy stack during minimally invasive procedures. Every surgeon is aware of this problem, especially during nights and on weekends, when experienced operating theatre assistants are not available. Conversions due to malfunction of the video-endoscopic equipment are reported. With the increased level of evidence proving superiority of the minimally invasive versus open approach, conversion induced by equipment failure become more and more problematic. The authors suggest a systematic way forward to troubleshooting laparoscopic tower equipment problems. Every surgeon performing laparoscopic surgery should read this paper and feel more confident with technical problems of the laparoscopy stack.

# Authors' Response to Reviewer Comments

Jul 31, 2017

I would like to thank you all the reviewers for their time (taken out of their busy clinical schedule) and valuable comments. I very much appreciate the. I have responded here to all the comments and suggestions as requested.

Reviewers' comments:

**Reviewer #1**:
It is a very important topic for all laparoscopic surgeons.
Some points are missing, e.g. what to do light source break down during the operation? Always check the life cycle of the light bulb before beginning the operation. It is almost impossible to change the bulb during the operation (very hot!), so there should be an extra light source.
Response:
• Thank you. This is covered in the table as 'Cable between the monitor and image producer loose/ Xenon lamp burned out'. But now I have drawn the attention of the readers to that particular phrase (light source break down during the operation) and addressed it.

The mentioned courses are very important. But normally every surgeons gets an instruction session before using the instruments or other technical devices. During these sessions, all kinds of possible problems are discussed to train the surgeon before the surgery. Therefore I see no real "danger" for patients, when surgeons didn't go to special courses or use strict algorithms. They should not learn by doing and have to be instructed, which can be done by several ways.
Response:
• I absolutely agree with the fact that things can be done in several ways and that is my whole point.
• Surgeons do not need to attend all courses and read all instructions prior to operating. But these courses and reading are important and emphasizes the safe use of various equipment including lap tower. The real danger exist when surgeons are not familiar and these courses, reading including my algorithm (any one of them) provide an avenue for safe practice.
• Not all surgeons (especially junior doctors) in all countries receive formal instruction session from industry representatives prior to using those instruments. The surgeon may have been taught the usage of that particular instrument by either industry representative, surgeon colleague, surgeon supervisor or surgeon mentor. In spite of any teaching/ instruction received it always helps to have a systematic approach (aided by an algorithm) to trouble shoot any issues with lap tower. And more over we all have different ways of learning and need reference document to refer to when in need irrespective of the knowledge or training. My algorithm only provides this and helps in maintenance of patient safety.

I don't agree the conclusion that "... surgeons, trainees and aspiring junior doctors have a deficiency in the technical knowledge...". These surgeons should not perform any laparoscopic operation before getting this knowledge. In Germany, surgeons have a device certificate for each device they use intraoperatively and are not allowed to use them without instruction.
These points should be mentioned in the manuscript.
Are there some data showing higher safety or less complications using e.g. a "problem-solving chart in operation theaters"?
Response:
• Not all of them have deficiency in knowledge. Some are better than the others. I have made appropriate changes to the sentence (varied knowledge) in the conclusion.
• It is fantastic that all surgeons are required to and have certification to every device that they use. But unfortunately it is not the case in most of the countries. In this event my algorithm provides a reference point for safe practice.
• There is data available showing that systematic/ checklist based approach when feasible and practical reduces complications (ref 11). WHO has clearly shown (not mentioned in the manuscript as it doesnt directly relate to lap tower trouble shooting) that a checklist when appropriate reduces adverse events in theatre, which has been the basis for introduction of widely accepted 'Pre operative WHO patient checklist'. Our checklist/ algorithm is along the same lines but addressing a specific component of the operating theatre.

**Reviewer #2**:
The authors have developed a helpful checklist for the surgeon to overcome technical problems with the laparoscopy stack during minimally invasive procedures. Every surgeon is aware of this problem, especially during nights and on weekends, when experienced operating theatre assistants are not available. Conversions due to malfunction of the video-endoscopic equipment are reported. With the increased level of evidence proving superiority of the minimally invasive versus open approach, conversion induced by equipment failure become more and more problematic. The authors suggest a systematic way forward to troubleshooting laparoscopic tower equipment problems. Every surgeon performing laparoscopic surgery should read this paper and feel more confident with technical problems of the laparoscopy stack.
Response:
Thank you very much for your kind words. Much appreciated

# Reviewers' Comments to Revision

## Reviewer 1: Thomas Carus

Aug 01, 2017

| | |
|---|---|
| **Reviewer Recommendation Term:** | Accept |
| **Overall Reviewer Manuscript Rating:** | 85 |

| **Custom Review Questions** | **Response** |
|---|---|
| Is the subject area appropriate for you? | 5 - High/Yes |
| Does the title clearly reflect the paper's content? | 5 - High/Yes |
| Does the abstract clearly reflect the paper's content? | 5 - High/Yes |
| Do the keywords clearly reflect the paper's content? | 5 - High/Yes |
| Does the introduction present the problem clearly? | 5 - High/Yes |
| Are the results/conclusions justified? | 4 |
| How comprehensive and up-to-date is the subject matter presented? | 4 |
| How adequate is the data presentation? | 4 |
| Are units and terminology used correctly? | 4 |
| Is the number of cases adequate? | N/A |
| Are the experimental methods/clinical studies adequate? | N/A |
| Is the length appropriate in relation to the content? | 4 |
| Does the reader get new insights from the article? | 4 |
| Please rate the practical significance. | 4 |
| Please rate the accuracy of methods. | N/A |
| Please rate the statistical evaluation and quality control. | N/A |
| Please rate the appropriateness of the figures and tables. | N/A |
| Please rate the appropriateness of the references. | 4 |
| Please evaluate the writing style and use of language. | 4 |
| Please judge the overall scientific quality of the manuscript. | 3 |
| Are you willing to review the revision of this manuscript? | Yes |

**Comments to Authors:**
Thank you for the Revision of your manuscript - everything fine now.