The American Journal of Surgery (2017) 213, 159-170

The American Journal of Surgery®

Review

Three-dimensional laparoscopy vs 2-dimensional laparoscopy with high-definition technology for abdominal surgery: a systematic review

Charlotte Fergo, B.Sc., M.B.B.S.[a,*], Jakob Burcharth, M.D., Ph.D.[b], Hans-Christian Pommergaard, M.D., Ph.D.[c], Niels Kildebro, M.D.[a], Jacob Rosenberg, M.D.[a]

[a]Center for Perioperative Optimization, Department of Surgery D, Herlev Hospital, University of Copenhagen, Herlev Ringvej 75, DK-2730 Herlev, Denmark; [b]Department of Surgery, Koege Sygehus, Koege, Denmark; [c]Department of Surgery, Hvidovre Hospital, University of Copenhagen, Hvidovre, Denmark

KEYWORDS:
Three-dimensional laparoscopy;
Imaging;
Minimally invasive surgery

Abstract

BACKGROUND: This systematic review investigates newer generation 3-dimensional (3D) laparoscopy vs 2-dimensional (2D) laparoscopy in terms of error rating, performance time, and subjective assessment as early comparisons have shown contradictory results due to technological shortcomings.

DATA SOURCES: This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Randomized controlled trials (RCTs) comparing newer generation 3D-laparoscopy with 2D-laparoscopy were included through searches in Pubmed, EMBASE, and Cochrane Central Register of Controlled Trials database.

CONCLUSIONS: Of 643 articles, 13 RCTs were included, of which 2 were clinical trials. Nine of 13 trials (69%) and 10 of 13 trials (77%) found a significant reduction in performance time and error, respectively, with the use of 3D-laparoscopy. Overall, 3D-laparoscopy was found to be superior or equal to 2D-laparoscopy. All trials featuring subjective evaluation found a superiority of 3D-laparoscopy. More clinical RCTs are still awaited for the convincing results to be reproduced.

The introduction of minimally invasive surgery has led to a reduction in complications. However, this has not been achieved without repercussions: the operative field depicted in 2 dimensions which results in a loss of true depth perception and the mechanical constraint from the instruments in small incision points have had some initial negative effects, especially on the learning curve.[1–3] Surgeons are required to compensate for the lack of a 3-dimensional (3D) image by using secondary visual references to interpret the nonstereo depth cues, a competence that experienced surgeons typically have learned to accomplish.

The positive effect of 3D visualization is also seen in robot-assisted surgery, which has become widely adopted due to additional potential advantages such as Endowrist technology facilitating tremor filtration and motion scaling. However, there is a lack of evidence of the superiority of

There were no relevant financial relationships or any sources of support in the form of grants, equipment, or drugs.

The authors declare no conflicts of interest.

* Corresponding author. Tel.: +45 51941110; fax: +45 38684009.
E-mail address: sayakafergo@hotmail.com

Manuscript received June 10, 2015; revised manuscript June 19, 2016

0002-9610/$ - see front matter © 2016 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.amjsurg.2016.07.030

robot-assisted surgery from high-quality evidence[4] and the increased attention to health economics calls for eligible alternatives.

Laparoscopy with 3D imaging has existed as an alternative for over 20 years. The camera system in modern 3D-laparoscopes consists of 2 adjacent cameras (bi-channel), which simulates the stereopsis obtained from the fusion of the slightly different views from the binocular disparity of the 2 human eyes, known as stereoscopy. The technologies described in this systematic review achieve stereoscopy by capturing 2 slightly different images of the same scene, which are displayed simultaneously but at different polarizations or spectras on a passive 3D-monitor. The images are received by each eye through passive glasses, thus allowing viewing only the left- and right-eye image with the corresponding eye by the aid of polarization or interference filters. The result is a fusion of the 2 images, similar to the direct view in stereopsis, and is perceived as a single image with increased depth perception.[3,5]

The benefits of introducing 3D-laparoscopy as a tool for improving surgical accuracy and patient safety seem apparent; however, early comparative trials of 3D-laparoscopic systems vs 2-dimensional (2D) laparoscopy have shown contradictory results. Some trials indicated stereoscopy as being the main reason for better outcome,[6,7] whereas other trials found no difference between the 2 optical systems.[8–10] Several trials have criticized the poor quality and tolerance as the illumination was found to be suboptimal and with more adverse effects, especially when standard 3D-laparoscopy was compared with 2D-laparoscopy with a higher resolution.[3,11] Since then, there has been an advancement in the technology of stereoscopy. The better illumination and resolution in the new generation 3D-laparoscopy with HD resolution probably render the results from earlier 3D-systems obsolete. The aim of this systematic review was to present an overview of the literature investigating randomized trials of 3D-laparoscopy vs 2D-laparoscopy with the use of HD resolution in terms of error rating, performance time, and subjective assessment.

Methods

Protocol and registration

This systematic review was registered through an international database of prospectively registered systematic reviews: Prospero (CRD42015015096) and was performed according to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[12]

Search strategy and selection criteria

A comprehensive literature search was performed at April 25, 2015 through the following databases: PubMed, EMBASE and Cochrane Central Register of Controlled Trials with the assistance from a Health Sciences librarian with an expertise in search strategies for systematic reviews. The search algorithm for PubMed was: (((((“Imaging, 3-dimensional“[MeSH terms]) and ″laparoscopy“[MeSH terms])) or ((((3-dimensional laparoscopy) or 3D-laparoscopy) or 3-dimensional laparoscopic) or 3D-laparoscopic))) and ((((((2-dimensional laparoscopy) or 2D-laparoscopy) or 2-dimensional laparoscopic) or 2D laparoscopic) or conventional laparoscopy) or conventional laparoscopic). An additional search in Google scholar has been performed and trials have been searched in clinicaltrials.gov, The WHO Clinical Trials Search Portal, and PROSPERO.

Retrieved articles were included only if they met the following inclusion criteria: prospective, randomized, controlled, experimental, or clinical trials (RCTs) comparing 3D-laparoscopy vs 2D-laparoscopy in abdominal, gynecological, or urological surgery from 2006 to present with laparoscopic systems using HD resolution in both modalities and passive 3D glasses. The electronic search was restricted to trials published from 2006 as newer generation 3D-laparoscopy was introduced that year.[13] The exclusion criteria were non-English articles, conference abstracts, non-published trials, animal trials, and laparoscopic systems with the use of anaglyph glasses, active shutter glasses, auto-stereoscopic, or head-mounted displays (Fig. 1).

Study selection and data items

Two investigators (CF and NK) assessed all titles and abstracts individually and any disagreements were resolved by discussion. The manufacturer of the optical systems or the authors of the included articles were contacted if not explicitly mentioning HD resolution or the use of passive 3D glasses. If trials only reported a total number of participants but not the exact number in each trial arm, we assumed that the number of participants in both trial arms were identical. For simplification, the tasks were classified post hoc into 2 groups: simple (eg bead/peg transfer, rope pass) and more complex tasks (eg knot tying and suturing).

Data extraction

Data extraction was performed by 2 reviewers (CF and NK) and included trial design, cohort size, experience level, task characteristics, optical systems used, and conclusions. The following outcomes were recorded: performance time was defined as time to task completion and/or total protocol time with results reported as absolute differences or differences in mean or median. Error rate was defined as differences in absolute number of errors or mean or median number of errors (total protocol or task specific). Errors were defined according to task. Subjective assessments were extracted whenever subjective evaluation or scoring of modalities in terms of feasibility, satisfaction, or technical features was present.