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Comparison of robot-assisted and conventional endoscopic abdominal surgeries in the Russian Federation: a systematic review and meta-analysis

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Abstract

Objective. To compare the results of robot-assisted (RA) and laparoscopic (LA) technologies in abdominal surgery in Russian surgical practice.

Material and methods. A systematic review and meta-analysis were conducted in accordance with methodological recommendations of the Russian Ministry of Health and the Cochrane guidelines. Considering heterogeneity of primary study designs, we did not determine the overall effect of meta-analysis. Differences were presented for each study. The review continues the 2021 study and updates data using similar inclusion criteria and approaches to meta-analysis.

Results. The number of studies devoted to abdominal robotic surgery has increased since 2020. Controlled non-randomized trials comprised 96%. Predominant area of research was oncological coloproctology. Duration of robotic surgeries varied from 113 to 665 min, laparoscopic surgeries — from 91 to 427 min. Differences in favor of shorter laparoscopic surgery were significant in half of the studies. The incidence of intraoperative complications in robotic interventions varied from 0% to 13%, in laparoscopic interventions — from 0% to 30%. There was a tendency to less blood loss in robotic interventions. Comparison of inpatient treatment, postoperative complications (0—56% after robotic interventions, 1—70.6% after laparoscopic surgeries) and mortality (0—8.7% after robotic surgery and 0—11.8% after laparoscopic interventions) did not reveal significant differences.

Conclusion. At the modern stage of robotic surgery in the Russian Federation, differences between robotic and traditional laparoscopic interventions are not significant in abdominal surgery. Further researches with higher methodological quality are needed due to low evidence base.

Keywords: *robot-assisted surgery, laparoscopic surgery, abdominal surgery, systematic review.*

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Introduction

Robotic surgery is one of the most dynamically developing areas of modern medicine. Robotic surgery combines achievements of engineering, computer science and medical technology. Over the past decades, the number of robot-assisted procedures has significantly increased that confirmed trust of doctors and patients in this innovative method of treatment. However, fast spread of robotic surgeries was mainly based on intuition and experience of surgeons, despite the lack of sufficient high-quality evidence of effectiveness and safety of such procedures [1].

Currently, robotic surgery covers various specialties, including urology, gynecology, cardiac and abdominal surgery. Despite the obvious advantages for surgeons, such as high accuracy of movements and favorable ergonomics, there are still important questions regarding short and long-term effectiveness, safety, costs and risk of complications compared to traditional laparoscopy. Systematic and large clinical trials with high evidence level are necessary to understanding how current technologies meet the benefits [2].

Further development of robotic surgery necessitates careful research to objectify safety and effectiveness of new methods. Only available significant and reproducible re-

sults will allow medical communities to make informed decisions about introduction of innovative technologies into everyday practice.

This study is a continuation of scientific searching began in 2021 whose aim was quantitative and qualitative assessment of Russian-language studies [3].

The purpose was t**o c**ompare the results of robot-assisted (RA) and laparoscopic (LA) technologies in abdominal surgery in Russian surgical practice.

Material and methods

This review was devoted to Russian researches. We used relevant regulatory documents adopted in the Russian Federation. For some aspects that have not yet been presented in national recommendations, we used the Cochrane recommendations (2024) [4—6].

Inclusion criteria

Study groups should be represented by robot-assisted endoscopic (RAE) and traditional video endoscopic (TVE) interventions among participants aged >18 years.

Outcomes

Studies should provide at least the following data: surgery time, blood loss, conversion rate, complication rate, postoperative hospital-stay.

Searching criteria

Searching was carried out in electronic library (elibrary.ru) and Cochrane Central Register of Controlled

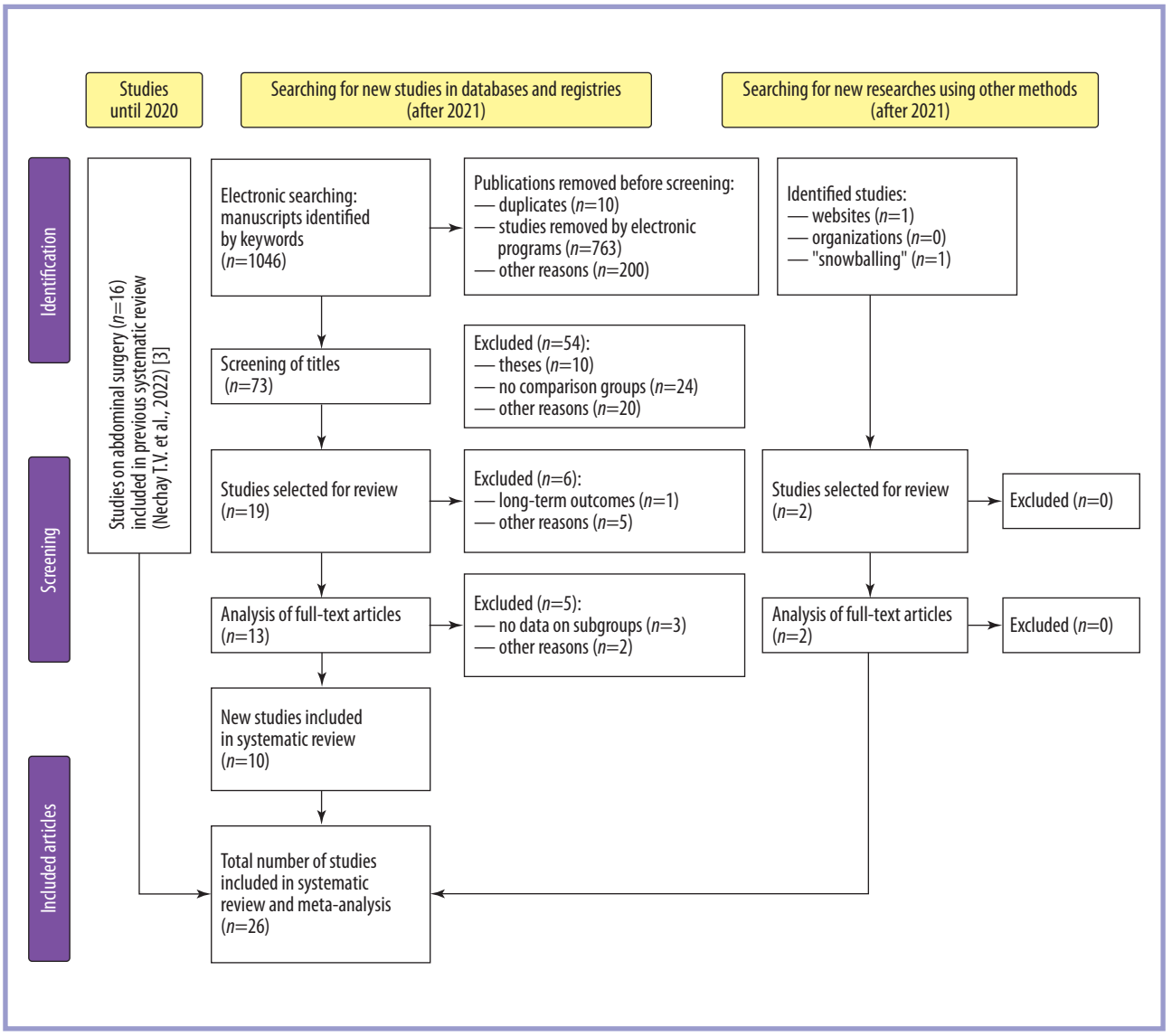


Fig. 1. **Study flowchart.**

Overall characteristics of studies

No.	Author, year	Study years	Disease	Procedure	**RA**/LA (total)
			Coloproctology		
1	Polovinkin V.V., 2024	2021—2023	Rectal cancer	Low anterior resection	**62**/55 (117)
2	Moiseev M.E., 2024	2015—2021	Rectal cancer	Rectum resection	**82**/128 (210)
3	Itkulov A.F., 2024	2014—2023	Complicated chronic diverticulitis	Sigmoid resection	**24**/28 (52)
4	Moiseev M.E., 2023	2015—2023	Rectal cancer	Rectal resection/abdominoperineal extirpation	**223**/240 (463)
5	Goncharov A.L., 2020	2017—2019	Colon cancer	Right hemicolectomy, left hemicolectomy, sigmoid resection	**69**/67 (136)
6	Stoyko Yu.M., 2019†	2010—2017	Colon cancer and diverticular colon disease	Right hemicolectomy, left hemicolectomy, colon resection, sigmoid resection, Hartmann's procedure	**20**/105 (125)
	Stoyko Yu.M., 2019†	2010—2017	Rectal cancer	Anterior rectal resection, low anterior rectal resection, abdominoanal resection, abdominoperineal extirpation	**76**/29 (105)
7	Murashko R.A., 2017	2015—2017 N1 2011—16 N2	Rectal and colon cancer	Right hemicolectomy, left hemicolectomy, colon resection, sigmoid resection, abdominoperineal extirpation, anterior rectal resection, low anterior rectal resection, abdominoanal resection, subtotal colectomy	**77**/123 (200)
8	Belyaev A.M., 2016	2013—2015	Malignant neoplasm of the right colon	Right hemicolectomy	**21**/31 (52)
9	Kazantseva M.V., 2016	2015 N1 2010—2015 N2	Rectal and colon cancer	Left hemicolectomy, anterior rectal resection, low anterior rectal resection, sigmoid resection, abdominoperineal extirpation	**30**/59 (89)
10	Gladyshev D.V., 2015	2013—2015	Colon cancer	Right hemicolectomy, left hemicolectomy, s igmoid resection, subtotal colectomy	**53**/59 (112)
			Hepatopancreatobiliary surgery		
11	Khatkov I.E., 2019	2007—2018	Hepatopancreatobiliary cancer	PDE	**30**/230 (260)
12	Popov A.Yu., 2018	2013—2018	Hepatopancreatobiliary cancer, pseudotumoral pancreatitis	PDE	**23**/17 (40*)
13	Shabunin A.V., 2018	2013—2017	Pancreatic cancer	Distal pancreatectomy	**15**/27 (42)
14	Kriger A.G., 2015	2009—2014	Pancreatic cancer T1—2, benign pancreatic diseases	Distal pancreatectomy	**19**/10 (29)
15	Berelavichus S.V., 2015	No data	Non-parasitic liver cysts	Liver resection	**8**/28 (36)
			Gastric resection		
16	Kovalenko S.A., 2024	2018—2022	Gastric cancer	Subtotal distal gastrectomy, total gastrectomy	**37**/19 (56*)
17	Chernousov A.F., 2020	2013—2019	Gastric GIST	Atypical gastric resection	**5**/25 (30)
18	Chernousov A.F., 2017	2013—2017	Gastric cancer stage IIIA—IV	Subtotal distal gastrectomy, total gastrectomy	**27**/2 (29)
			Gastric surgery (GERD)		
19	Mimishev R.V., 2024	2016—2024	GERD recurrence ± hiatal hernia	Redo fundoplication	**14**/13 (27)
20	Shestakov A.L., 2023	2016—2022	GERD ± hiatal hernia type 1	Nissen fundoplication	**154**/358 (512)

Overall characteristics of studies (*end*)

No.	Author, year	Study years	Disease	Procedure	**RA**/LA (total)
			Gastric surgery (GERD)		
21	Komarov R.N., 2022	2015—2021	GERD ± hiatal hernia	Chernousov fundoplication	**32**/32 (64)
22	Koshkin M.A., 2021**	2017—2018	GERD + hiatal hernia	Chernousov fundoplication	**40**/46 (86)
23	Semenyakin I.V., 2019	2015—2019	Hiatal hernia	Laparoscopic fundoplication	**72**/291 (363)
			Other surgeries		
24	Aboyan I.A., 2020	No data	Adrenal cancer	Adrenalectomy	**32**/56 (88)
25	Berelavichus S.V., 2015	2007—2014	Non-parasitic spleen cysts	Spleen resection	**10**/11 (21)
26	Semenov D.Yu., 2012	2004—2011	Adrenal diseases	Adrenalectomy	**45**/118 (163)

Note: * — laparotomies were not considered; ** — RCTs (all other studies are non-RCTs); † — one publication; PDE — pancreatoduodenectomy; GIST — gastrointestinal stromal tumor.

Trials (CENTRAL). The last one also includes abstracts from PubMed, Embase, CINAHL and ClinicalTrials.gov databases. Russian-language searching was conducted until 01.09.2025. Studies were relevant for inclusion if they compared patients who underwent laparoscopic and robotic procedures. To verify studies, we initially used a broad searching strategy taking into account nature of pathology and extent of surgery. Searching was carried out using medical headers (MeSH terms) and AND/OR unions (robot OR robotic OR robotic OR robotic-assisted OR robotic surgeries OR robotic-assisted surgeries OR laparoscopic surgeries).

In electronic library (elibrary.ru), searching was carried out in titles, keywords and abstracts. We additionally introduced headings on the subject (76.00.00 — medical sciences).

Searching in other resources

In discovered studies and systematic reviews, we performed manual searching for references to other suitable studies of the second and subsequent levels using the snowballing method. This made it possible to find additional publications by analyzing references in previously selected studies. The second level searching was carried out through screening of contents of medical journals with published articles that were found at the first level in archive of issues from 2021 to 2025. The PubMed database was searched for full-text articles in Russian by abstracts in English. The ClinicalTrials.gov database was screened for completed studies (including unpublished ones).

Collection of information and systematization of data

Selection of studies

Several authors collected evidence base independently of each other. After identification, screening and reading of abstracts, the authors evaluated full-text studies regarding eligibility taking into account exclusion criteria.

Exclusion criteria:

— studies without statistical analysis;
— studies comparing open and minimally invasive interventions without distinguishing robotic and laparoscopic ones in the last group;
— studies without comparison groups;
— studies evaluating only long-term outcomes of interventions;
— no full-text article;
— studies available as abstracts;
— reviews without own data.

Any discrepancies were reviewed jointly with other authors. The entire phase is documented as a PRISMA flowchart [7].

Retrieving data

For each study, several co-authors collected the following data: name of the first author, year of publication, disease, type of intervention, sample size and study design features determining evidence level. Outcome data included intra- and postoperative complications, mortality, surgery time, conversion rate, blood loss, and hospital-stay. Accuracy of information was confirmed by other authors.

Assessing the internal validity

Cochrane Risk of Bias Tool 2.0 (RoB 2) was used to assess risk of bias in randomized clinical trials (RCTs), Risk of Bias In Non-randomised Studies of Interventions (ROBINS-I) – for the same purpose in non-randomized clinical trials (non-RCTs) [8, 9].

Treatment effect estimation and data synthesis

Differences between continuous data were established using mean difference, between dichotomous data — using odds ratio (OR). We analyzed significance of between-group differences considering 95% confidence interval and p-value. Necessary additional calculations of mean and standard deviation were carried out using appropriate formulas [10].

Meta-analysis was performed in RevMan 5.4 using the Inverse Variance method. The random effect model was selected due to high heterogeneity of studies and their designs. One author performed statistical calculations whose accuracy was confirmed by the second author.

Analysis of studies

A meta-analysis combined information from non-RCTs and RCTs that is acceptable [11]. Moreover, we presented differences for each study without overall effect of meta-analysis due to heterogeneity of study designs and risk of potentially false conclusions [11].

Working with missing data

Basic information necessary for evaluation of robotic and laparoscopic surgeries was presented in studies. Additional clarifying contacts with authors of primary studies were not required.

Heterogeneity assessment

We proceeded from a priori high heterogeneity of non-RCTs [9, 11].

Subgroup analysis and assessment of heterogeneity

Subgroup analyses were based on the area of interest of robotic interventions: coloproctology, hepatopancreatobiliary surgery, gastric surgery and other surgeries. Only one study was of a protocol nature, and we did not perform subgroup analysis based on study design (RCTs and non-RCTs).

Sensitivity

We did not analyze sensitivity considering quality of evidence base (25 (96%) comparative non-RCMs among 26 trials) and features of metadata presentation (without overall effect of meta-analysis).

Results

Study design

Almost all (25 out of 26) national studies correspond to controlled/comparative non-RCTs **(Fig. 1)** [12—36]. One trial was carried out with randomization, as well as without prior protocol registration, description of randomization method and latent allocation method [37]. Formalized assessment (RoB 2 and ROBINS-I) showed satisfactory internal validity of these studies.

Scientific searching in various fields of robotic surgeries in the Russian Federation

Ten out of 26 studies are devoted to coloproctology. The second largest part (n=8) is gastric surgery (gastric resection — 3 trials, interventions for gastroesophageal reflux disease and hiatal hernia — 5 studies). Hepatopancreatobiliary surgery is represented by 5 studies, other surgeries — by 3 trials.

There were 3507 patients including 1300 (37.1%) ones in the RA group and 2207 (62.9%) in the LA group. The number of patients scheduled for robotic intervention did not exceed 20 in 7 studies, for laparoscopy — in 6 trials. Characteristics of studies [12—37] are presented in **Table.**

Surgery time

Necessary data on surgery time were presented in 24 studies. Laparoscopic procedures were shorter in time. Duration of robotic interventions varied from 113 to 665 min, endoscopic procedures — from 91 to 427 min. In 13 trials (mainly in coloproctology and hepatopancreatobiliary surgery), differences in favor of shorter duration of laparoscopic surgeries were significant. Thus, robotic surgeries were significantly longer in 5 out of 11 studies in coloproctology (by 25 min). The same was true for hepatopancreatoduodenal surgery (3 out of 4 studies) with mean difference 35 min. In gastric surgery, significant differences for shorter duration of laparoscopic interventions were indicated in 4 out of 8 studies **(Fig. 2a)**.

Intraoperative blood loss

Intraoperative blood loss was assessed in 18 trials, and between-group differences were significant in 10 ones (8 in favor of RA surgery, 2 in favor of laparoscopy). There is a tendency for less blood loss in RA surgery (19—470 vs. 23—833 ml) **(Fig. 2b)**.

Incidence and types of intraoperative complications

Safety of RA surgery regarding intraoperative complications was assessed in 12 articles. There were no intraoperative complications in 3 reports, and other 9 studies demonstrated significant differences in the incidence of intraoperative complications. The incidence of complications following robotic surgeries varies from 0 to 13%, laparoscopic interventions — from 0 to 30% **(Fig. 2c)**.

Incidence and causes of conversions

Conversion rates are presented in 21 publications. There were no differences in conversion rates (3.9%

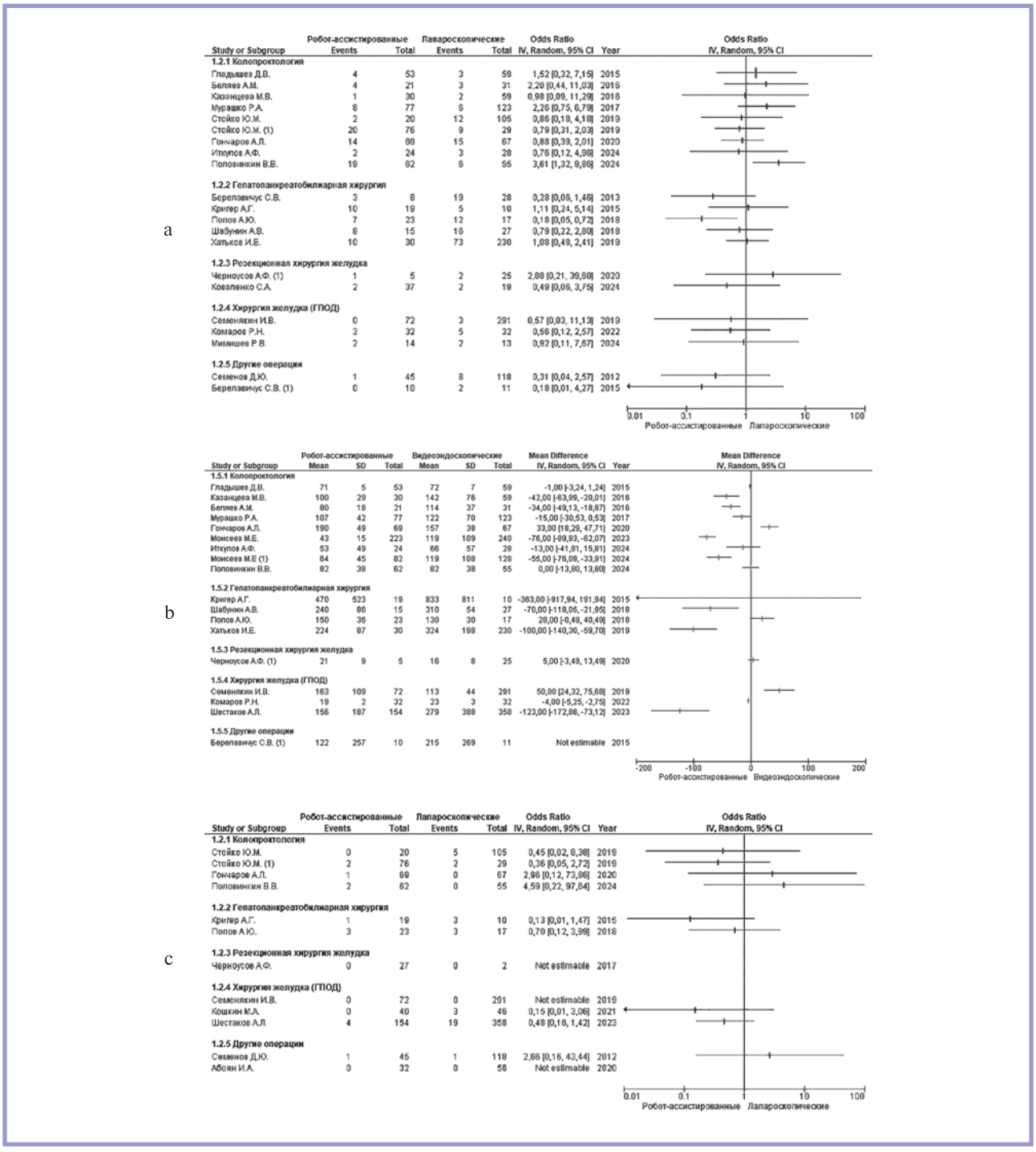


Fig. 2. **Intraoperative characteristics.**
a — duration of surgical interventions; b — intraoperative blood loss; c — incidence of intraoperative complications.

in groups). The probability of conversion varies from 0 to 26% for RA surgery and from 0 to 11.7% for laparoscopic procedures. Four studies found no conversions for robotic and laparoscopic interventions. All other studies revealed no significant differences in conversion rates. In 11 authors (including 8 studies on coloproctology), conversions were rarer for robotic surgeries, in 6 trials — for laparoscopic procedures **(Fig. 3a)**.

Hospital-stay

Data on postoperative hospital-stay are presented in 16 trials. Postoperative hospital-stay varied approximately within the same range in groups depending on disease and extent of surgery (3.1—16 days after RA surgery and 3.1—16.1 days for laparoscopy). Five authors reported significantly shorter hospital-stay after robot-assisted surgery, and other ones found no differences **(Fig. 3b)**.

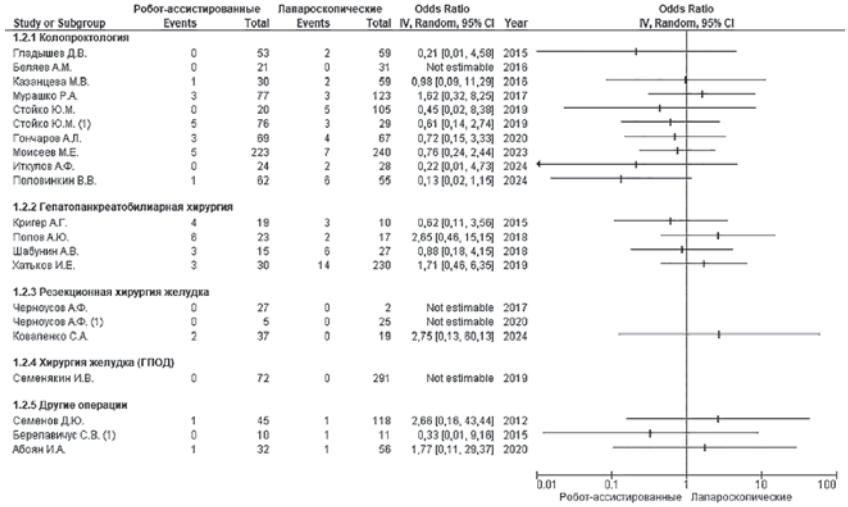
Postoperative complications

Postoperative morbidity is presented in 21 studies (16.3% after robotic and 15.1% after laparoscopic surgeries). RA surgery was followed by complications in 0—56% of cases, laparoscopic surgery — in 1—70.6% of cases. However, there were no significant differences in any study. Fourteen trials indicate a trend towards lower incidence of complications after RA surgery; 7 trials demonstrate an opposite trend. The incidence of postoperative complications is presented in **Fig. 4a**.

Mortality

Data on mortality are available in 19 studies. There were no fatal cases in 11 trials, and other 8 studies found no significant differences. Mortality rate ranged from 0 to 8.7% after RA surgeries and from 0 to 11.8% after laparoscopic interventions **(Fig. 4b)**.

a



b

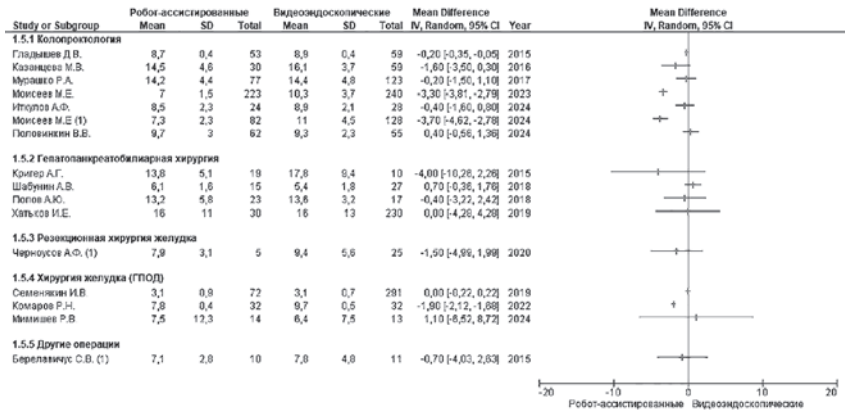


Fig. 3. **Analysis of conversion rate and hospital-stay.**

Discussion

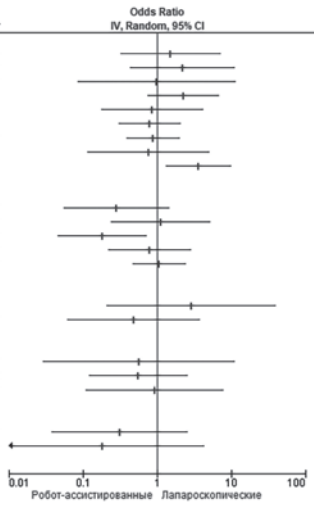
Despite the small absolute number of robotic platforms in the Russian Federation (<40), the number of appropriate surgeries exceeds several tens of thousands. So, more than 5.7 thousand interventions were performed in 2024. Accumulation of extensive statistical data, interest of professional surgical communities, and allocation of robotic surgery in separate sections at specialized conferences stimulated generalization of experience in robot-assisted interventions. At the same time, only 4 comparative studies were published in the Russian Federation (only one with evidence level 2) for 5 years (2021—2025) against more than 1800 for the same period in the world (0.2% of world evidence base). The total number of patients who underwent abdominal robot-assisted surgeries included in studies for the entire period of robotic surgery in the Russian Federation does not exceed 1300. Three are no new studies containing synthesis and integral assessment of data on robotic surgery in the Russian Federation.

Available data demonstrate the tendency to less blood loss in RA surgery and no significant differences in intraoperative complications, conversion, postoperative complications and mortality. These trends may be compromised by high heterogeneity of primary studies and do not reach statistical significance or represented by subclinical significance.

Our results were compared with modern foreign studies with high evidence base. Yang L. et al. [38] analyzed 6 RCTs (832 patients) devoted to robot-assisted surgery for colorectal cancer. The authors found no differences in length of hospital stay, blood loss, bowel function recovery rate, conver-

a

Study or Subgroup	Робот-ассистированные Events	Total	Лапароскопические Events	Total	Odds Ratio IV, Random, 95% CI	Year
1.2.1 Колопроктология						
Гладышев Д.В.	4	53	3	59	1,52 [0,32, 7,15]	2015
Беляев А.М.	4	21	3	31	2,20 [0,44, 11,03]	2016
Казанцева М.В.	1	30	2	59	0,98 [0,09, 11,29]	2016
Мурашко Р.А.	8	77	6	123	2,26 [0,75, 6,79]	2017
Стойко Ю.М.	2	20	12	105	0,86 [0,18, 4,18]	2019
Стойко Ю.М. (1)	20	76	9	29	0,79 [0,31, 2,03]	2019
Гончаров А.Л.	14	69	15	67	0,88 [0,39, 2,01]	2020
Иткулов А.Ф.	2	24	3	28	0,76 [0,12, 4,96]	2024
Половинкин В.В.	19	62	6	55	3,61 [1,32, 9,86]	2024
1.2.2 Гепатопанкреатобилиарная хирургия						
Берепавичус С.В.	3	8	19	28	0,28 [0,06, 1,46]	2013
Кригер А.Г.	10	19	5	10	1,11 [0,24, 5,14]	2015
Попов А.Ю.	7	23	12	17	0,18 [0,05, 0,72]	2018
Шабунин А.В.	8	15	16	27	0,79 [0,22, 2,80]	2018
Хатьков И.Е.	10	30	73	230	1,08 [0,48, 2,41]	2019
1.2.3 Резекционная хирургия желудка						
Черноусов А.Ф. (1)	1	5	2	25	2,88 [0,21, 39,68]	2020
Коваленко С.А.	2	37	2	19	0,49 [0,06, 3,75]	2024
1.2.4 Хирургия желудка (ГПОД)						
Семенякин И.В.	0	72	3	291	0,57 [0,03, 11,13]	2019
Комаров Р.Н.	3	32	5	32	0,56 [0,12, 2,57]	2022
Мимишев Р.В.	2	14	2	13	0,92 [0,11, 7,67]	2024
1.2.5 Другие операции						
Семенов Д.Ю.	1	45	8	118	0,31 [0,04, 2,57]	2012
Берепавичус С.В. (1)	0	10	2	11	0,18 [0,01, 4,27]	2015



b

Study or Subgroup	Робот-ассистированные Events	Total	Видеоэндоскопические Events	Total	Odds Ratio IV, Random, 95% CI	Year
1.1.1 Колопроктология						
Гладышев Д.В.	0	53	0	59	Not estimable	2015
Беляев А.М.	0	21	2	31	0,27 [0,01, 6,01]	2016
Казанцева М.В.	1	30	0	59	6,05 [0,24, 153,10]	2016
Мурашко Р.А.	0	77	1	123	0,53 [0,02, 13,10]	2017
Стойко Ю.М.	0	20	1	105	1,70 [0,07, 43,19]	2019
Стойко Ю.М. (1)	0	76	0	29	Not estimable	2019
Гончаров А.Л.	0	69	0	67	Not estimable	2020
Иткулов А.Ф.	0	24	1	28	0,37 [0,01, 9,62]	2024
Половинкин В.В.	0	62	1	55	0,29 [0,01, 7,28]	2024
1.1.2 Гепатопанкреатобилиарная хирургия						
Кригер А.Г.	0	19	0	10	Not estimable	2015
Попов А.Ю.	2	23	2	17	0,71 [0,09, 5,65]	2018
Хатьков И.Е.	1	30	14	230	0,53 [0,07, 4,20]	2019
1.1.3 Резекционная хирургия желудка						
Черноусов А.Ф. (1)	0	5	0	25	Not estimable	2020
Коваленко С.А.	0	37	0	19	Not estimable	2024
1.1.4 Хирургия желудка (ГПОД)						
Семенякин И.В.	0	72	0	291	Not estimable	2019
Мимишев Р.В.	0	14	0	13	Not estimable	2024
1.1.5 Другие операции						
Семенов Д.Ю.	0	45	0	118	Not estimable	2012
Берепавичус С.В. (1)	0	10	0	11	Not estimable	2015
Абоян И.А.	0	32	0	56	Not estimable	2020

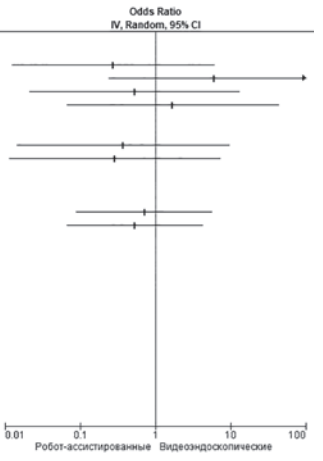


Fig. 4. **Analysis of postoperative complications and mortality.**

sion rate, number of excised lymph nodes, complication rate and CRM+ resection rate. At the same time, duration and cost of robot-assisted interventions were higher. Cuk R. et al. [39] analyzed treatment outcomes in 13,799 patients and obtained very low evidence base for benefits of RA surgery in colon cancer regarding surgical safety and postoperative complications compared to laparoscopic procedures. The authors clarified the prevalence of non-RCTs that put the conclusions at serious risk for objectivity. Gahunia S. et al. [40] presented the most extensive (34,846 patients) study and found advantages of RA surgery regarding conversion rate in obese patients and males with low cancer, as well as regarding length of hospital-stay in obese patients. At the same time, length of hospital stay, blood loss, incidence of complications and number of removed lymph nodes were comparable in other subgroups.

In liver resection surgery, a meta-analysis of 12 studies (Wang J. et al., 2021 [41]) included 751 patients (297 in RA surgery) and demonstrated laparoscopy-like efficacy (R0 resection rate, length of hospital stay) and safety (conversion rate, blood loss and transfusion rate, complications and mortality) with longer duration and cost of interventions.

According to systematic review and meta-analysis of 44 studies (38 RCTs), robot-assisted pancreatoduodenectomy likely has some advantages over traditional laparoscopic surgery although both approaches apparently provide equivalent clinical outcomes [42]. The authors noted predominant cohort studies as a negative factor for evidence quality and pointed to the need for high-quality RCTs comparing both approaches.

In gastric cancer surgery, Wang J. et al. (2024) [43] noted no significant between-group differences in length of hospital stay, incidence of complications, blood loss or number of excised lymph nodes. At the same time, there were differences in the incidence of severe complications (pancreatic fistula, anastomosis failure and intra-abdominal abscess).

There are 4 meta-analyses devoted to robot-assisted Nissen surgery in adults. Mirza W. et al. (2025) [44] presented the latest one. Considering 4 RCTs, the authors concluded that robot-assisted and traditional Nissen laparoscopic fundoplication provide similar clinical outcomes without significant differences in morbidity, quality of life and long-term efficacy. Robotic procedures are invariably longer and substantially more expensive, as well as not accompanied by obvious clinical benefits. These results challenge the feasibility of robotic platforms in anti-reflux surgery until cost-effectiveness is optimized. Probably, the last statement could be offset by emergence of more affordable robotic platforms, but until now Intuitive Surgical is almost a monopolist.

There were certain limitations in this systematic review and meta-analysis. The main causes of significant heterogeneity are heterogeneous designs and approaches to assessing intra- and postoperative parameters in primary studies. In addition, some missing data should be noted. In this regard, traditional synthesis of information with overall effect of meta-analysis was extremely difficult and could lead to false conclusions. This provided an alternative approach to final presentation of results.

Perhaps, a single comprehensive register is necessary to expand the evidence base for robotic surgeries in our country. National prospective high-quality studies are obviously needed.

Thus, the main conclusion of current analysis based on assessment of 26 modern trials in abdominal surgery has not changed: robot-assisted technologies do not worsen or improve treatment outcomes. Until now, it is impossible to confirm the effectiveness (ideal efficiency) of robot-assisted surgeries at the first evidence level.

Conclusion

At the current stage of robotic surgery in the Russian Federation, the differences between robotic and traditional endoscopic interventions in abdominal surgery are insignificant. Low evidence level necessitates further studies of higher methodological quality.

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