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# Local *VS.* other forms of anesthesia for open inguinal hernia repair: A meta-analysis of randomized controlled trials☆,☆☆

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ABSTRACT

*Background:* There is variation in the anesthetic technique for open inguinal hernia repair (OIHR) worldwide. Factors determining the anesthetic technique remains equivocal. We hypothesize that outcomes and operative room times are superior with local anesthesia (LA) compared to AO [all others (general and spinal anesthesia)].

*Methods:* Following PRISMA guidelines and set inclusion and exclusion criteria, various databases were reviewed and 18 RCT's were isolated. Using ReviewManager 5.3, multiple parameters were used to test for overall effect between the included studies.

*Results:* Overall complication rate was similar in LA *vs.* AO ($p = 0.06$). Wound infection and hematomas were similar between LA *vs.* OA, but urinary retention was significantly decreased in LA ($p = 0.0002$). Patient satisfaction was not inferior with LA ($p = 0.10$). Surgical time was similar in LA *vs.* AO ($p = 0.86$), but operating room time was significantly decreased with LA ($p < 0.0001$). The literature review also showed a decrease in the LOS and cost when LA was used.

*Conclusion:* This meta-analysis demonstrates that LA is a well-tolerated for OIHR with OR times and urinary retention being significantly decreased.



## Introduction

Inguinal hernia repair is one of the most common operations performed by general surgeons in the United States and worldwide.[1,2] Thus, any and all aspects regarding this common operation should be investigated to improve outcomes and reduce health care cost. Empirical observations in the United States suggest that the most common type of anesthesia for open inguinal hernia repair (OIHR) is general anesthesia (GA). However, there are several reports that indicate superior outcomes with local anesthesia (LA) compared to all other types (AO).[3–21] Additionally, LA is the most common type of anesthesia in hernia specialize hernias centers such as the Shouldice or Lichtenstein Hernia Institutes.[22–24] It is unclear why LA is underutilized in the United States.

Two prior meta-analyses assessed LA *vs.* GA (Reece-Smith et al.) and LA versus SA (Prakash et al.), but no previous meta-analysis has compared LA to AO.[25,26] The comparison by Reece-Smith et al. was equivocal regarding the superiority of LA because there were only five randomized controlled trials included in the analysis.[25] The results from Prakash et al. which included ten RCTs, favored the use of LA over SA.[26] Since their publication, more laparoscopic repairs have occurred, there is more of an impetus for watchful waiting of inguinal hernias and even robotic inguinal hernia has emerged as a possible alternative for patient with inguinal hernias. The present meta-analysis was undertaken with the following specific aims[1]: assess the outcomes of patient undergoing LA *vs.* AO OIHR including complications, patient satisfaction, and cost[2]; identify factors that might dictate underutilization of LA in the United States compared to centers of excellence for hernia repair. We hypothesize that LA has superior outcomes compared to AO and that patient satisfaction with LA will be higher compared to AO.

☆ All Authors have contributed scientifically to this manuscript according to the ICMJE criteria.

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## Methods

This meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines by two independent reviewers.[27] A thorough literature search was performed in May 2018 (no time restriction was placed) using the online databases: PubMed, MEDLINE, Ovid Syntax, The Cochrane Library, and Google Scholar. The terms utilized in this search were "inguinal hernia repair", AND/OR "open inguinal hernia repair", AND/OR "surgery", AND/OR "local anesthesia", AND/OR "regional anesthesia", AND/OR "general anesthesia", AND/OR "anesthesia", AND/OR "randomized controlled trial". Additionally, hand searches were performed on Google. All studies were compiled in an EndNote group and all duplicates were removed. A total of 83 manuscripts were collected.

Following, all the studies were assessed based on relevance and predetermined inclusion and exclusion criteria. The PRISMA flow chart included depicts the screening process (Fig. 1).[27] The two independent reviewers (MA and JF) analyzed the abstract of each study within the EndNote group to eliminate irrelevant studies, such as review articles, articles addressing the history and evolution of inguinal hernia repairs, and articles describing anesthetic techniques. The two reviewers then assessed the remaining studies using the inclusion and exclusion criteria stated below.

### *Inclusion criteria*

The following terms were used for inclusion: Open inguinal hernia repairs**,** use of local anesthesia**,** direct comparison of local anesthesia to another form of anesthesia and randomized controlled trials.

### *Exclusion criteria*

Papers excluded for analysis included: Laparoscopic surgical technique, bilateral open hernia repairs, recurrent open hernia repairs, pediatric patients, and retrospective or comparative studies.

Once the remaining studies were compiled, each full-text article was reviewed, and the pertinent information was collected on an Excel spreadsheet. This included the year of publication, the number of patients in each study arm, the parameters recorded (complications, length of stay, patient satisfaction, OR time, etc.), and the duration of the study. If articles were not printed in English, Google Translate was used to translate the study to English.[5,10,16] If the full-text articles were not accessible or if Google Translate did not accurately translate values, these studies were excluded. After compiling the study information, study design was verified and only randomized controlled trials were included. This strategy yielded a total of 18 studies ranging from 1976 to 2017 for the final

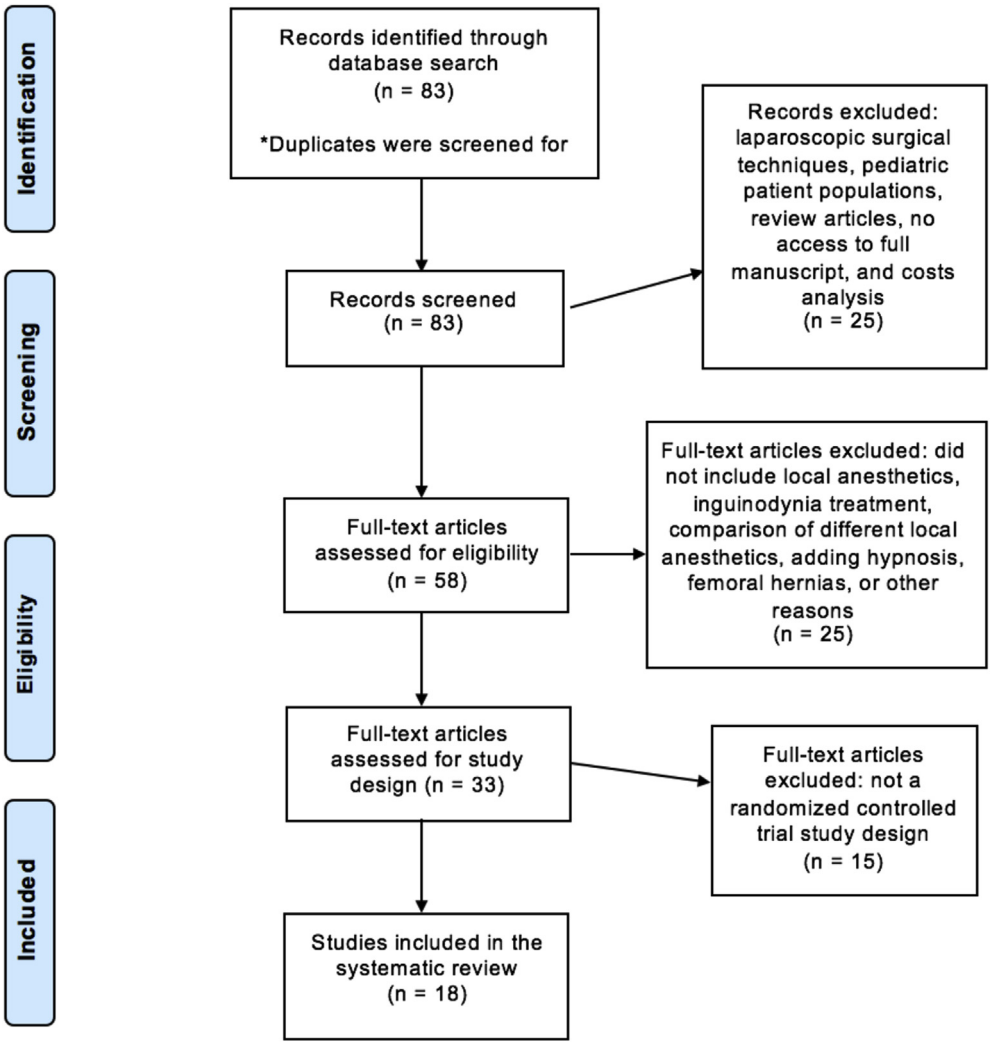


**Fig. 1.** PRISMA flow-chart describing the process of our literature search.

meta-analysis.

*Statistical methods*

Statistical analysis of the data was completed using Review Manager 5.3 program.[28] For the studies with sufficient data, Forest plots were created comparing the occurrence of total events respective to either the use of LA or AO. Each comparison included only the studies that reported the specific parameter. For comparisons that assessed the overall effect between continuous variables, such as surgical time, the mean and standard deviation (SD) was used. For studies comparing three different forms of anesthesia, the two non-local forms were averaged together (i.e. regional averaged with general). If the mean was not reported, the median was used. If the SD was not reported, it was calculated by multiplying the interquartile range (IQR) by 0.75 or the range by 0.25 as previously reported elsewhere.[7,29] A random-effects model was used to account for the variance in true effect size that differed between each study. This was decided based on the level of heterogeneity, defined by $I^2 > 50\%$, present in each comparison. A $p$-value of $<0.05$ was used to signify significance.

## Results

*Overall complications*

After compiling and analyzing the 18 journal articles, the overall trend favored LA over AO when performing OIHR, however only two comparisons met significance (urinary retention and total operating room time). The overall complication rate favored LA when compared to AO in OIHR but did not reach significance ($p = 0.06$; OR = 0.62; 95% CI [0.43, 1.03]) (Fig. 2). Specifically, the rate of urinary retention was significantly increased amongst the patients undergoing AO – including regional or general anesthesia ($p = 0.0002$; OR = 0.13; 95% CI [0.05, 0.44]). There was no difference in the rate of wound infections ($p = 0.17$; OR = 1.39; 95% CI [0.88,

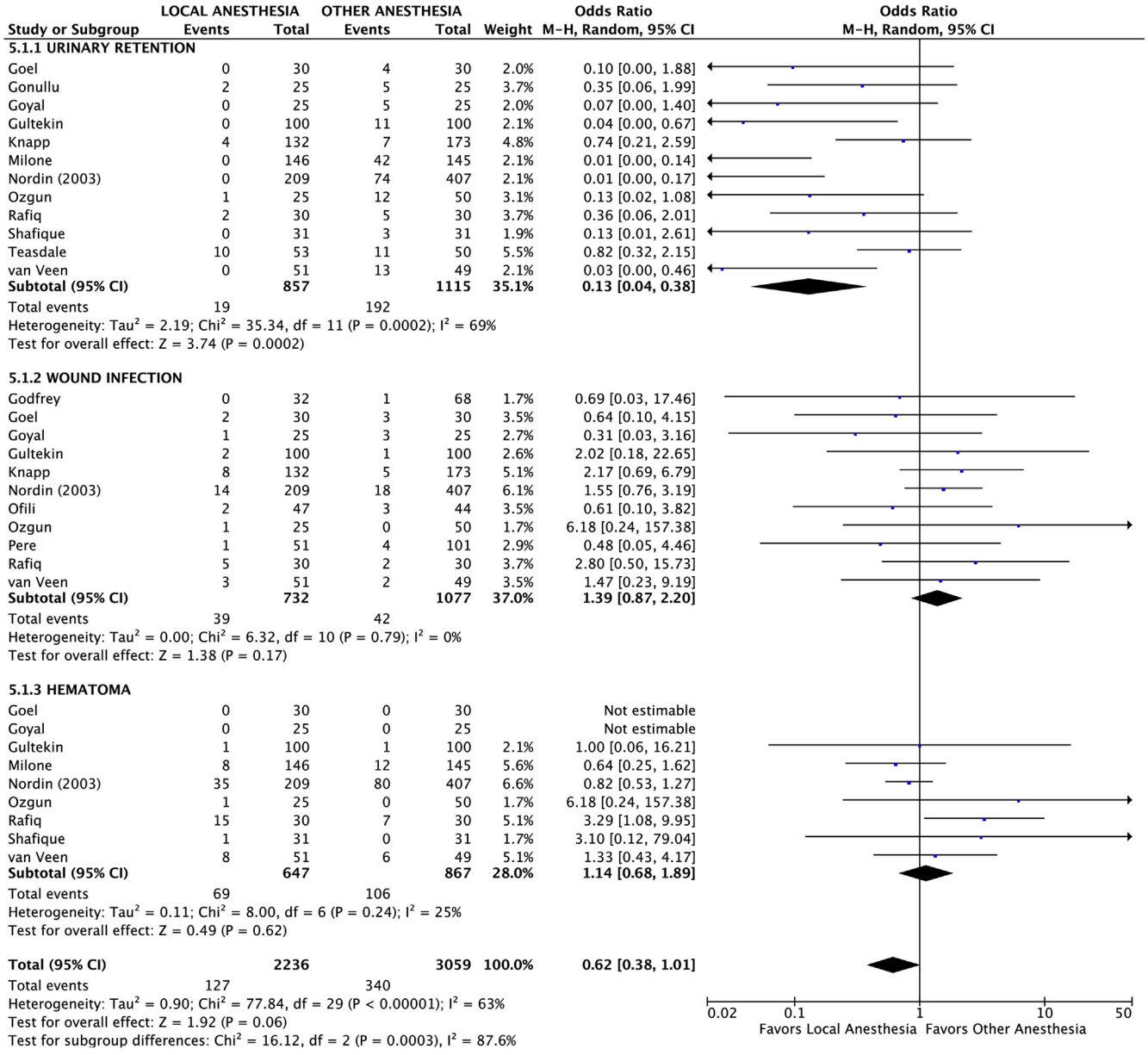


**Fig. 2.** Forest plot comparing postoperative complications.

2.11]). The hematoma rate was similar for both LA and AO ($p = 0.64$; OR = 1.14; 95% CI [0.74, 1.65]). The forest plot for the various complications and their overall effect is shown in Fig. 2.

### *Patient satisfaction*

Individuals undergoing an OIHR under LA reported the same degree of satisfaction as AO ($p = 0.03$; OR = 2.23; 95% CI [0.97, 1.37]) (Fig. 3). Shafique et al. reported high satisfaction in 28 or their 31 (90.3%) patients who underwent an OIHR under LA, but satisfaction was not recorded in the comparison group who received spinal anesthesia therefore there were not included in the forest plot depicted in Fig. 3.[21]

### *Surgical times*

An analysis of operative time (operation skin to skin) between the seven studies that recorded it revealed no difference between LA and AO ($p = 0.86$; 95% CI [-7.21,8.69]) (Fig. 4). Knapp and Mullen (mean surgical time: LA = 59 min & AO = 56.1min) and Ofili et al. (mean surgical time: 35min for both LA and GA) did not include standard deviation or any measure of dispersion of their data set therefore they were excluded from the statistical analysis, but both LA and AO had similar results.[30,31] Goel et al. (mean time taken to complete operation: LA = 72 min & AO = 51.5 min) was also excluded from the statistical analysis because standard deviation was not reported, however their results did show a difference in total surgical time between LA and AO.

We also compared the total operative room time (defined as the time at which the patient entered the OR to when the patient left the OR) between LA and AO as multiple studies made the distinction in their collected data. When analyzing the seven studies that recorded this information there was a significant decrease in the total time spent in the operating room when using LA ($p < 0.0001$; 95% CI [-16.59, −5.94]) (Fig. 5).

### *Hospital length of stay (LOS)*

Due to the heterogeneity of reporting in LOS, it was not possible to perform formal statistical analyses, but the majority of studies that recorded this parameter were noted to have a significantly decreased LOS in the LA arm.[3,5,6,11,12,17,19] Table 1 displays this as well as their respective *p*-values.

### *Postoperative pain*

Postoperative pain respective to each anesthesia technique was reported frequently in the studies. A direct comparison was not possible as pain was measured differently between the studies and specific statistical numbers were not always reported. Thus, Table 2 was created to exhibit the studies that monitored postoperative pain and their respective findings. The respective *p*-values were included in the table as well. Four of the eleven studies reveal a significant decrease in postoperative pain when LA is used[10,3,14,6] of the seven remaining studies, the average pain experienced by individuals following LA was diminished when compared to AO.[4,9,11,17,19]

### *Cost*

Cost was reported in 4 papers, only 3 of the papers were available for full text.[32–34] However, due to the heterogeneity of the data that was reported, there was no formal statistical analysis. Instead, this data is presented in a tabular form (Table 3), which demonstrated that LA was less expensive than AO in all aspects (costs of anesthetic materials, intraoperative and early postoperative costs, and in total healthcare costs).

### *Geographic distribution of studies*

Only one article out of the 18 was performed in the United States in the year 1976.[30] Most of the studies were published in Europe (11 of the 18). There was no evidence of any RCTs for the Shouldice or

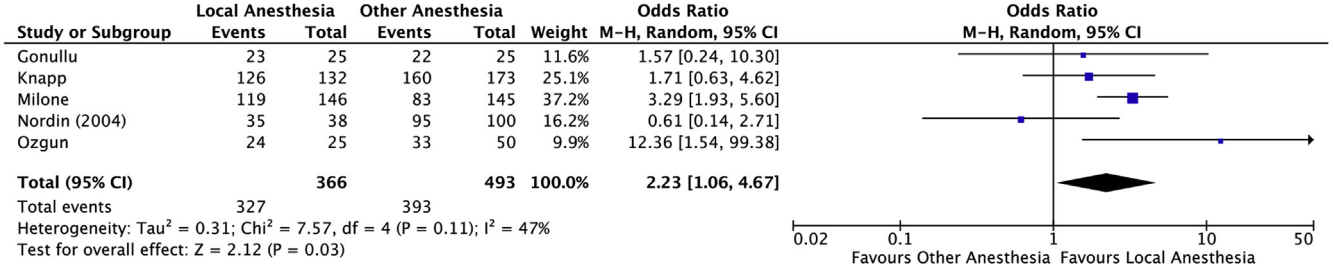


**Fig. 3.** Forest plot comparing postoperative patient satisfaction with their respective anesthesia.

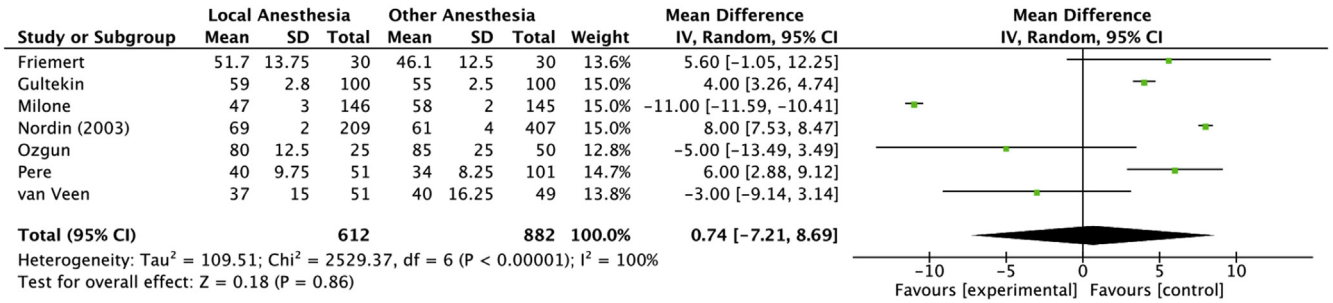


**Fig. 4.** Forest plot comparing total surgical time between local anesthesia and other forms of anesthesia.

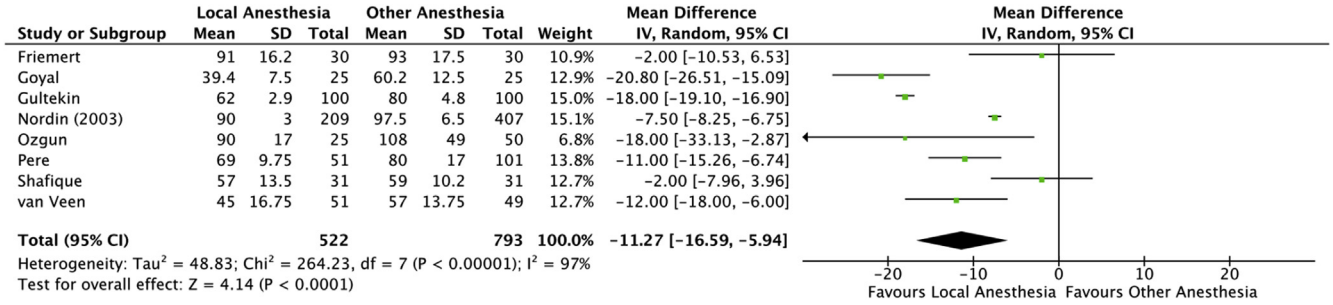


**Fig. 5.** Forest plot comparing total operating room time between local anesthesia and other forms of anesthesia.

**Table 1**
Length of hospital stay.

| Length of Hospital Stay | | | | |
|---|---|---|---|---|
| Author | Variable | Local Anesthesia | Other Anesthesia | *p* - value |
| Godfrey (1981) | | n = 32 | n = 68 | |
| | one night stay | 31 | 66 | N/A |
| | greater than one night stay | 1 | 2 | |
| Goyal (2014) | | n = 25 | n = 25 | |
| | average length of stay (days) | 1.76 ± 1.2 | 2.32 ± 1.46 | <0.05 |
| Knapp (1976) | | n = 118 | n = 173 | |
| | average length of stay (days) | 13.7 | 10.3 | N/A |
| Milone (2010) | | n = 146 | n = 145 | |
| | one day surgery | 129 | 27 | 0.001 |
| Nordin (2003) | | n = 209 | n = 407 | |
| | length of stay in hours | 3.1 | 6.2 | <0.0001 |
| Ozgun (2002) | | n = 25 | n = 50 (GA:25 & RA:25) | |
| | average length of stay (hours) | 22 | GA: 28 SA: 20 | <0.004 |
| Pere (2016) | | n = 51 | n = 100 (GA:52 & RA:49) | |
| | average time to discharge (min) | 93 | GA: 142 SA: 190 | <0.001 |
| Rafiq (2016) | | n = 30 | n = 30 | |
| | average length of stay (days) | 3 ± 1.2 | 6 ± 1.6 | 0.00 |
| Teasdale (1982) | | n = 53 | n = 50 | |
| | number of patients discharged at 24 h | 46 | 47 | N/A |
| van Veen (2008) | | n = 51 | n = 49 | |
| | unplanned overnight admissions | 2 | 12 | 0.004 |

*N/A: study did not report.
◦ "-": not-significant.

Lichtenstein Institutes of Hernia Surgery regarding LA vs. AO for OIHR.

## Discussion

In general, this meta-analysis demonstrates that most studies have superior outcomes with LA compared to AO. Multiple other studies have shown similar benefits to LA in OIHR. Huntington et al. reported patients receiving LA over GA have improved post-operative quality of life.[8] The meta-analysis conducted by Prakash et al. evaluating LA against spinal anesthesia reported significantly less pain in the LA group ($p < 0.01$), significantly increased satisfaction with the anesthesia method ($p < 0.01$), and lower rates of urinary retention ($p < 0.01$).[7] The other previous meta-analyses comparing LA to GA in five trials reported reduction in nausea and an accelerated return to normal social activities when LA was utilized.[25] Though, this same study did not find a significant difference in urinary retention, return to work, surgical time, or operating room time therefore they concluded anesthetic technique should be at the preference of the patient and surgeon.[25]

Arguments against LA include increased intraoperative pain experienced by patients, which Goel et al. and Goyal et al. reported.[6,35] In the prospective randomized study by Goel et al. sixteen of the 30 individuals who received LA reported intraoperative VAS scores ≥4 whereas only one individual receiving spinal anesthesia reported VAS ≥ 4.[35] Goyal et al. revealed the opposite and reported a significant decreased in intraoperative pain when comparing local to spinal anesthesia ($p < 0.05$).[6] Intraoperative pain was not widely studied therefore an overall effect cannot be concluded, but considering patients' overall high satisfaction following an OIHR under LA, intraoperative pain does not appear to play a significant factor. O'Dwyer conducted a RCT assessing local versus general anesthesia for OIHR (with 11 femoral hernia repairs included) and found no major differences between complications, recovery, or costs.[36] Their group believes that due to these similarities, patients should be offered their choice of anesthesia.[36] This study and the meta-analysis performed by Reece-Smith et al. do not show a clear benefit, which may be true for their individual comparisons. However, when incorporating the 18 RCTs included in this meta-analysis, there is a clear benefit with respect to postoperative urinary retention, operating room time, and overall healthcare costs (preoperative and postoperative acute care units for example).

The rate of urinary retention in this meta-analysis is higher than previously reported in retrospective studies. It is unclear why this occurred, but it might be due to the fact that RCTs are able to capture more complications accurately. Also RCTs are typically undertaken at academic centers that might undertake more complex hernias compared to the private sector and patients with higher comorbid conditions might experience a higher rate of

**Table 2**
VAS recorded at rest at 24 h postoperatively unless otherwise specified.

| Postoperative Pain | | | | |
|---|---|---|---|---|
| Author | Local Anesthesia | Other Anesthesia | | *p* - value |
| **Friemert** | n = 30<br>1.5 (0.25–2.75) | n = 30<br>2 (0.15–3.5) | | <0.05 |
| **Goel** | n = 30 | n = 30 | | |
| | 3.43 | 3.68 | | not sig |
| **Gonulu** | n = 25 | n = 25 | | |
| | 1.2 ± 1.1 | 1.8 ± 1.4 | | <0.05 |
| **Goyal** | n = 25 | n = 25 | | |
| | 2.00 ± 1.00 | 2.72 ± 1.13 | | 0.022 |
| **Gultekin** | n = 100 | n = 100 | | |
| | 2.1 ± 1.234 | 2.4 ± 1.149 | | 0.785 |
| **Nordin (2003)** | n = 205 | RA = 198 | GA = 199 | |
| | 1.8 (1.6–2.0) | 3.0 (2.7–3.2) | 3.3 (3.0–3.5) | <0.0001 |
| **Nordin (2004)** | n = 40 | RA = 52 | GA = 46 | |
| | 5.3 | 5.4 | 5.5 | not sig |
| **Ozgun** | n = 25 | RA = 25 | GA = 25 | |
| scale: 100 mm VAS | 20 | 30 | 30 | not sig |
| **Rafiq** | n = 30 | n = 30 | | |
| patients with severe pain<br>patients with moderate pain<br>patients with mild pain | 2<br>5<br>23 | 3<br>7<br>20 | | not sig |
| **Shafique** | n = 31 | n = 31 | | |
| VAS at 12hr postop | 38.4 ± 7.4 | 47.8 ± 7.9 | | not sig |
| **van Veen** | n = 49 | n = 49 | | |
| VAS at 8hr postop | 1.1 | 1.2 | | not sig |

**Table 3**
Cost comparisons between different anesthetic techniques reported in US dollars.

| Cost of Open Inguinal Hernia Repairs Based on Anesthesia Type | | | | |
|---|---|---|---|---|
| Author | Variable | Local Anesthesia | General Anesthesia | Regional Anesthesia |
| Bourgon (2015) | total healthcare costs | $6845 | $7839 | - |
| Kendell (2000) | cost of anesthetic materials | $86 | $131 | $140 |
| Nordin (2007) | intraoperative and early postoperative costs | $1810 | $2017 | $1951 |

urinary retention.

Other considerations during OIHRs include the operative and hospital costs involved with the operation. Callesen et al. evaluated the cost of infiltrative (local), spinal, and general anesthesia and found that infiltrative was less expensive (at least £160 less) and reported most of the savings stemmed from observation facilities required pre and post-operative as well as the pre-anesthesia evaluation needed.[37] Similarly, Kendell et al. performed a study assessing the costs of various anesthesia methods utilized in 1144 elective procedures. The median material cost of intravenous sedation and local block anesthesia for the 29 individuals included was £67 ($86) – considerably less than the cost of general anesthesia (£102; $131) or central nerve block (£109; $140) ($p = 0.0005$).[33] This study focused on three main anesthetic expenditures: staff time, consumables, and capital costs. They noted that when field block and sedation are used for hernia repair, the consumable costs and recovery time are much lower. The use of field block hastened recovery permits patients to bypass a costly postoperative acute care unit all together.[33] Furthermore, Nordin et al. showed that both the intraoperative and early postoperative costs were considerably lower in LA versus regional and general anesthesia.[34] The intraoperative costs of LA averaged €1568 ($1810) compared to €1690–1747 ($1951–2017) for regional and general anesthesia ($p < 0.001$). The early postoperative costs of local averaged €140 ($162) compared to €303–329 ($350–380) for regional and general ($p < 0.001$). Bourgon et al. analyzed the total healthcare cost of three methods of hernia repair – locoregional anesthesia, general anesthesia, and laparoscopic procedure and found similar results favoring open inguinal hernia repairs under locoregional anesthesia.[32] The adjusted means were locoregional

($6845), general ($7839), and laparoscopic ($11,340).[32] Bourgon et al. also reported hospital-based acute care encounters between the three groups and found no significant difference, but there was a significant difference ($p = 0.02$) between emergency department visits within the 30 day postoperative period (locoregional = 3.8%, GA = 4.7%, laparoscopic = 5.0%).[32]

In the United States OIHR is typically a day surgery procedure and other countries might have a higher hospital LOS compared to the US based on social rather than surgical needs such that this might not compute for cost in US based studies.[38,39]

Based on our literature search it is evident that most of the studies on choice of anesthetic for OIHR are performed outside of the United States. It is unclear why studies assessing this information are not more commonly done in the United States. One hypothesis is that highly specialized centers are more prevalent in European countries and thus they can compile large cohorts of patients necessary to assess these outcome measures. Another possible factor might be that other countries have less access to general anesthesia compared to the US. Factors associated with this discrepancy were not catalogued. It is possible that the higher use of general anesthesia in the United States is driven by surgeon's preference as well as concern for patient discomfort intraoperatively. Additional studies need to be undertaken to further understand these factors.

A major limitation encountered during this comparison occurred when evaluating recorded data that used different units. For example, the LOS could not be analyzed across the multiple studies because each study utilized a different unit to measure the patient's length of stay (minutes, hours, or days). Therefore, this review was only able to collect the statistical findings regarding the LOS from each separate study and compile it into one table. The inconsistency of measurements was also noted when analyzing post-operative pain scores. For post-operative pain evaluation, multiple studies used VAS to measure patients' pain, but this was recorded at different post-operative times limiting a formal statistical comparison. Fortunately, the difference between measurements of various studies did not limit all comparisons, for example, surgical time and operating room time were able to be directly compared after converting the variance (SD, IQR) using a technique by Hozo et al.[29]

## Conclusion

The use of LA in OIHRs introduces many benefits including shorter operative time, lower operative costs, less urinary retention, shorter LOS – as well as introducing the possibility of extending surgery to a cohort of patients who would be considered high risk general anesthesia candidates. Therefore, in an uncomplicated, unilateral open hernia repair, encouraging the use of local anesthesia in facilities beside specialty surgical centers is needed to ensure all the benefits of this anesthetic form are being utilized. Strategies to make general surgeons and patients in the United States should be developed such that LA is more widely utilized.

## Author contribution

Madison Argo was the primary data gathering investigator including data collection and analysis. She drafted the first version of the manuscript and was involved in all revisions. J Favela was involved with study design, drafting of the manuscript and revisions. T Phung was involved with drafting of the manuscript and critical revisions. S Huerta conceived the idea for the study, was involved in drafting the first version of the manuscript, he is responsible for all the data provided in the manuscript, and coordinated all aspects of the paper leading to the submission.

## Disclosure/conflict of interest

None of the authors have any conflicts of interests to disclose.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.06.024.

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