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## Review Article

## Economic and Environmental Impacts of the Wide-Awake, Local Anesthesia, No Tourniquet (WALANT) Technique in Hand Surgery: A Review of the Literature

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The United States spends more on health care than any other country in the world based on the percentage of gross domestic product. This fact is coupled with health care facilities contributing nearly one-tenth of all greenhouse gas emissions in the United States, and with the health care industry's waste contributions to landfills being second only to those of the food industry. In some instances, operating rooms produce the majority of total landfill waste from hospitals; therefore, patients undergoing surgical procedures can have both financial and environmental impacts. Recently, the wide-awake, local anesthesia, no tourniquet technique in hand surgery has grown in popularity. This technique has reportedly allowed surgeons to decrease operating room costs, time, and waste, but without compromising patient safety or outcomes. This comprehensive literature review summarizes the current literature related to the economic and environmental impacts of the wide-awake, local anesthesia, no tourniquet technique in hand surgery.

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The United States is known for its historically high health care expenditures. In 2018, health care spending grew 4.6%, reaching \$3.6 trillion (\$11,172 per person), and accounting for 17.7% of the nation's gross domestic product.<sup>1</sup> In 2007, US health care facilities contributed 8% to 10% of total greenhouse gas emissions and 9% of US air pollutants, and were second only to the food industry in contributions to landfills.<sup>2,3</sup> Operating rooms produce 20% to 70% of total waste in hospitals; therefore, surgical procedures can have financial and environmental impacts that should be taken into consideration when considering surgical interventions.

Hand surgeons are generally considered high-volume surgeons, as they routinely perform a breadth of surgeries on the hand and upper extremity, including but not limited to nerve, tendon, joint, fracture, and soft-tissue surgeries. Carpal tunnel release (CTR) is one of the most common surgeries performed among all

orthopedic surgeries, with its incidence continuing to increase.<sup>3</sup> In Ontario, Canada, the annual procedure rate for CTR surgery among patients aged >75 years increased from 22 per 10,000 in 1992 to 26 per 10,000 in 1996.<sup>4</sup> Similarly, Fajardo et al reported a 38% increase in CTR surgeries performed between 1996 and 2006 in the United States.<sup>5</sup>

Recently, wide-awake, local anesthesia, no tourniquet (WALANT) hand surgery has grown in popularity, with a number of reported benefits regarding its safety, efficiency, cost savings, and waste reduction.<sup>3,6,7</sup> However, as of 2017, only 19.5% of CTRs performed nationally were performed with local anesthesia.<sup>8</sup> Given the current trend of an increasing hand surgical volume and the anticipated accompanying increased environmental impact, the purported benefits of WALANT hand surgery have never been more urgent. This comprehensive literature review intends to summarize the current, available literature related to the cost efficiency and environmental impacts of WALANT hand surgery.

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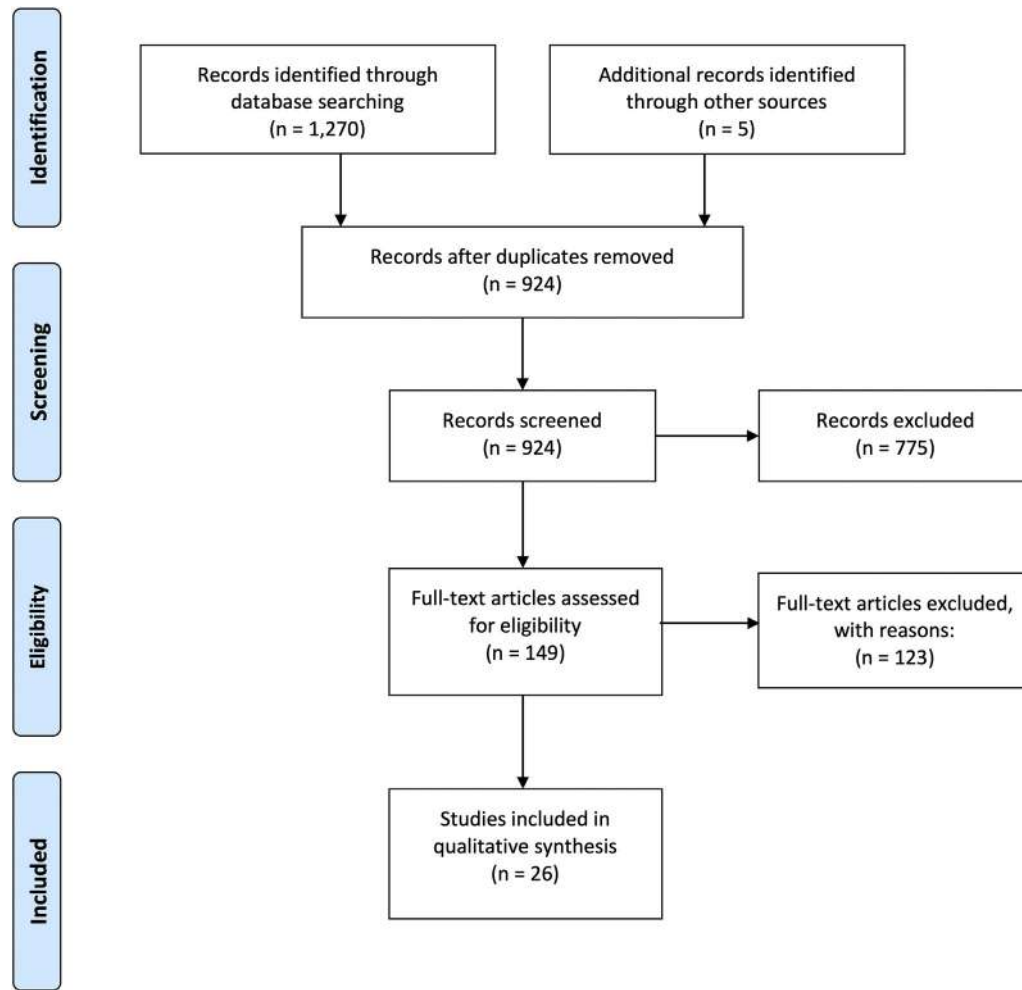
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## Literature Search

A systematic literature search of the PubMed, Ovid/MEDLINE, Cochrane, Google Scholar, and EMBASE databases was performed

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**Figure.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram detailing the literature search performed.

using the following keywords: “WALANT,” “wide awake local anesthesia no tourniquet,” “wide awake local anesthesia hand surgery,” “wide awake local anesthesia,” “wide awake hand surgery,” and “local anesthesia hand surgery.” Article screening was performed by 2 authors (D.B., and C.B.T.; Fig.). Article titles and abstracts were initially screened for relevance. Full-text review was performed for 149 articles for inclusion in the review, and bibliographies were reviewed for additional relevant articles. In total, 26 articles were included that directly related to the financial and/or environmental effects of wide-awake hand surgery, regardless of the surgical setting, what country the study took place in, or the level of evidence. All included articles are summarized in the Table. Because of the substantial differences in the health care and financial systems of the many countries of included articles, and because of many relevant articles being based on personal experience or observation studies, a literature review was performed rather than a systematic review. Of note, studies included in this review were performed in a mix of operating room settings, which could have their own economic and environmental effects distinct from the effects of the WALANT technique.

### Preoperative Cost Savings

Generally, preoperative medical clearance testing is not required in WALANT surgery, as compared to in surgery performed under

general anesthesia. Preoperative medical clearance often requires a combination of laboratories (complete blood cell count, basic metabolic panel), electrocardiography, chest radiographs, and office visits, depending on the specific surgery center protocols and the patient’s health status. In a cost analysis comparing CTR performed with WALANT versus intravenous sedation, Alter et al<sup>10</sup> estimated that WALANT patients saved an average of \$235 in these preoperative costs compared to patients whose surgery was performed under intravenous sedation.

Additional nonmedical-related costs saved by patients include time missed from work and additional travel costs saved by not requiring preoperative visits and testing. This saves patients from taking paid or unpaid leave from work in order to complete preoperative testing. Additionally, WALANT hand surgery patients do not require an escort on their surgery day, which is convenient for the patient and may save a third party from missed work and transportation costs. It would be extremely difficult to quantify the nonmedical costs saved by patients and third parties because of the wide variability in individual patient circumstances; however, with the high volume of potential WALANT hand surgeries, these costs and time savings could be substantial.

Patient comfort and the patient experience are also improved before surgery in WALANT hand surgery, as patients are not required to fast before surgery, and patients do not require intravenous catheter placement for anesthesia.<sup>6,17,31,32</sup> Patients

**Table**  
Summary of Articles Reporting on the Economic or Environmental Impact of the WALANT Technique

#	Article	Study Type	Level of Evidence	Purpose	Cost Savings
1	Albert and Rothkopf, 2015 <sup>9</sup> (USA)	Cost analysis	V	Authors identified disposable supplies and instruments that are routinely opened and wasted in common plastic and hand surgery procedures, and calculated the savings that can result from eliminating extraneous items. A cost analysis was performed, which compared the expense of operating room waste versus single-stream recycling and the benefit of recycling HIPAA documents and blue wrap.	<ul style="list-style-type: none"> <li>• Fifteen total items were removed from disposable plastic packs, and 7 total items were removed from hand packs.</li> <li>• Based on the annual number of these common procedures performed, an estimated total of \$17,381.05 could be saved per year with leaner packs.</li> <li>• Single-stream recycling saved \$3,487 per month at the 3 campuses.</li> <li>• Authors extrapolated and estimated savings of \$41,844 per year.</li> </ul>
2	Alter et al, 2018 <sup>10</sup> (USA)	Retrospective cohort	III	Comparison of intraoperative (operating room) surgical time and postoperative (postanesthesia care unit) time for consecutive CTR procedures performed under both intravenous sedation and WALANT. Cost of anesthesia services was also analyzed.	<ul style="list-style-type: none"> <li>• \$139 to \$432 was saved in each case performed with WALANT by not using anesthesia services.</li> <li>• Between \$1,320 and \$1,613 was saved for the full episode of care for each patient with WALANT, including preoperative testing and PACU time.</li> </ul>
3	Bismil et al, 2012 <sup>11</sup> (UK)	Retrospective case series	IV	To analyze the cost efficiency of the “1-stop” WALANT hand surgery service in the United Kingdom, in which patients are seen and treated in the same appointment.	<ul style="list-style-type: none"> <li>• Over 10 years of using the 1-stop wide-awake hand surgery service, the equivalent of over \$2.5 million US dollars was saved.</li> </ul>
4	Bravo et al, 2020 <sup>3</sup> (USA)	Review	n/a	Propose multiple ways to reduce both material and nonmaterial waste-energy consumption, through sterilization techniques, reprocessing of devices, patient transportation, production of surgical supply, anesthesia, and sanitation in hand surgery, which can lead to cost savings and decrease carbon footprint.	<ul style="list-style-type: none"> <li>• Open procedures have a smaller carbon footprint than endoscopic and arthroscopic procedures, because of the lower energy consumption of the specialized equipment.</li> <li>• Widespread adoption of local anesthesia during CTR would amount to \$2.3 billion in savings over the next decade. If those procedures were also performed through the open method, savings would increase to \$3.6 billion/decade, while reducing waste.</li> </ul>
5	Caggiano et al, 2015 <sup>12</sup> (USA)	Retrospective cohort	IV	Compare the nonsurgical operating room time (time from ending a case to starting the next case) between WALANT cases versus cases with MAC or general anesthesia.	<ul style="list-style-type: none"> <li>• WALANT cases resulted in significantly decreased total nonsurgical operating room time between cases (<math>P &lt; .05</math>).</li> <li>• Decreased total nonsurgical time by 40% compared with general anesthesia hand cases.</li> </ul>
6	Cantlon and Yang, 2017 <sup>13</sup> (USA)	Review	n/a	Reviewed different aspects of WALANT surgery, including cost effectiveness and patient satisfaction.	<ul style="list-style-type: none"> <li>• The amount of waste generated from a WALANT procedure is a fraction of that generated from the same case in the main operating room and, consequently, cleaning and turnover times drop significantly.</li> <li>• Less time for patient in recovery.</li> </ul>
7	Carr et al, 2019 <sup>14</sup> (USA)	Prospective cohort	II	A direct-cost analysis of a single surgeon performing an open CTR in the operating room, OSC, and clinic was completed. Four treatment groups were included, with 5 cases in each group: (1) the hospital operating room with MAC (operating room-MAC), (2) OSC with MAC (OSC-MAC), (3) OSC with local anesthesia (OSC-local), (4) and clinic with local anesthesia (clinic). Then, direct costs were calculated.	<ul style="list-style-type: none"> <li>• Average direct costs were \$213.75 for the operating room, \$102.79 for the OSC-MAC, \$55.66 for the OSC-local, and \$31.71 for the clinic group.</li> <li>• The average weight of surgical waste was the 4.78 kg in the operating room, 2.78 kg in the OSC-MAC, 2.6 kg in the OSC-local, and 0.65 kg in the clinic group.</li> <li>• The clinic's direct costs and surgical waste were significantly lower than those in all other settings (<math>P &lt; .005</math>).</li> <li>• Reduced most waste by using reusable towels for draping.</li> <li>• CTR was almost 7 times more expensive in the operating room than the clinic.</li> </ul>
8	Chatterjee et al, 2011 <sup>15</sup> (USA)	Retrospective cost-analysis	III	A detailed cost analysis for all CTR completed at a tertiary care academic center in 2007. Authors calculated the net revenues and profit margins for single endoscopic port and open CTS performed in the operating room and clinic.	<ul style="list-style-type: none"> <li>• The total cost per case when performing a single-port endoscopic CTS was \$2,273 vs \$985 when performed in the operating room versus the clinic, respectively.</li> <li>• For open CTS, the operating room was more than 4 times as expensive as the clinic (\$3,469 vs \$670, respectively).</li> <li>• For single endoscopic port cases, profits gained were greater than double in the clinic versus the operating room (\$2,710 vs \$1,139, respectively).</li> <li>• For open CTS, clinic cases had a profit margin per case of \$1,186; however, procedures in the operating room incurred a loss of \$650 per case.</li> <li>• When adding in the opportunity cost of lost time and delays in the hospital, the true costs per case were \$6,169 for the hospital cases and \$670 for the clinic cases.</li> <li>• This resulted in a true profit of \$1,186 for cases done in the clinic and a loss of \$3,349 per case for hospital-based cases.</li> </ul>
9	Codding et al, 2017 <sup>16</sup> (USA)	Retrospective cohort	III	Consecutive cases of single TFR surgery with MAC were compared with WALANT.	<ul style="list-style-type: none"> <li>• Operating room time was the same in WALANT and MAC cases.</li> <li>• Main difference was each case performed under MAC had a minimum of excess charges from anesthesia of approximately \$105 and significantly less time in the PACU.</li> <li>• Average PACU time for the MAC group was 62.9 min (range, 45–101 min), vs average WALANT time of 30.2 min (<math>P &lt; .01</math>).</li> </ul>

Table (continued)

#	Article	Study Type	Level of Evidence	Purpose	Cost Savings
10	Davison et al, 2013 <sup>17</sup> (Canada)	Prospective cohort	II	100 consecutive WALANT CTRs were completed in New Brunswick, Canada, compared to 100 CTRs with intravenous sedation in Iowa, USA; then, a survey was collected 1 week after surgery.	<ul style="list-style-type: none"> <li>Wide-awake patients spent less time at the hospital (2.6 h) than sedated patients (4.0 h; <math>P &lt; .001</math>). Preoperative blood work, electrocardiograms, and/or chest radiographs were done for 3% of wide-awake patients and 48% of sedated patients (<math>P &lt; .001</math>).</li> <li>Narcotics were used by 5% of unsedated patients and 67% of sedated patients (<math>P &lt; .001</math>).</li> </ul>
11	Foster et al, 2017 <sup>8</sup> (USA)	Retrospective cohort, private insurance database	III	Using the PearlDiver Patient Records Database, the CPT codes for elective CTR from 2007–2011 were searched. Type of anesthesia (ie, general and regional anesthesia vs local anesthesia) and surgical approach (ie, endoscopic vs open) were recorded. Cost analysis, patient demographics, regional variation, and annual changes in CTR surgery were analyzed.	<ul style="list-style-type: none"> <li>86,687 patients were identified.</li> <li>Most underwent open CTR (83.9%) and used general anesthesia (80.5%).</li> <li>16.1% were endoscopic, and were found to be the costliest, at \$794 more expensive than open CTR.</li> <li>General and sedation \$654 more expensive than local anesthesia.</li> </ul>
12	Gillis and Williams, 2017 <sup>18</sup> (Canada)	Retrospective cohort, cost analysis	III	Authors analyzed the cost and efficiency of performing CRIF of hand fractures in the operating room versus in the clinic in Canada.	<ul style="list-style-type: none"> <li>The costs of performing a CRIF in the operating room under local anesthesia, not including surgeon compensation, are \$461.27 CAD versus \$115.59 CAD in the ambulatory setting, a 299% increase.</li> <li>The use of a regional block increases the cost to \$665.49 CAD, a 476% increase.</li> </ul>
13	Kamal and Behal, 2019 <sup>19</sup> (USA)	Prospective cohort	II	To evaluate total patient time and costs after implementing a quality improvement initiative for CTR, which included it being performed wide awake with local anesthesia.	<ul style="list-style-type: none"> <li>Compared to CTR performed under MAC, CTR performed wide awake with local anesthesia resulted in a 31% reduction in total direct costs (including operating room services, pharmaceuticals, and supplies), and a significant decrease in total patient time at the ambulatory surgery center.</li> </ul>
14	Kazmers et al, 2018 <sup>20</sup> (USA)	Retrospective cohort, cost analysis	III	To evaluate whether the anesthesia type or the surgical setting had an effect on total costs and payments in CTR.	<ul style="list-style-type: none"> <li>CTR performed in a procedure room under WALANT resulted in lower total direct costs and total combined payments than in all other combinations of surgery location and anesthesia type evaluated.</li> </ul>
15	Kritiotis et al, 2019 <sup>21</sup> (UK)	Personal observation, comparative	V	Comparing the experiences of WALANT hand surgery between the United Kingdom and Cyprus.	<ul style="list-style-type: none"> <li>In Cyprus, performing trapeziectomy under WALANT is nearly 75% more cost effective for the patient than when performed under general anesthesia.</li> <li>In the United Kingdom, WALANT results in significant cost savings for the National Health Service and decreased waiting times for surgery for patients.</li> </ul>
16	Leblanc et al, 2007 <sup>22</sup> (Canada)	Retrospective cohort, cost analysis	III	To compare the costs of performing CTR in a main operating room versus in an ambulatory surgery center in Canada.	<ul style="list-style-type: none"> <li>Supplies plus labor costs for 1 CTR are \$137/case in the main operating room, versus \$36/case in an ambulatory setting.</li> <li>In 3 hours, 9 CTRs can be performed in ambulatory setting, versus 4 CTRs in the main operating room.</li> <li>37% of Canadian surgeons exclusively use the ambulatory setting for CTR.</li> </ul>
17	Lalonde and Martin, 2014 <sup>6</sup> (Canada)	Review	n/a	Review the main concepts of WALANT surgery and cost effectiveness.	<ul style="list-style-type: none"> <li>There are many cost savings associated with WALANT, including saving on the anesthesiologist, the recovery room staff, and preoperative testing. They have found that there is improved communication, which in turn decreases complication rates and increases patient satisfaction.</li> </ul>
18	Lalonde, 2019 <sup>7</sup> (Canada)	Review	n/a	Review on latest advances in WALANT, including cost benefits.	<ul style="list-style-type: none"> <li>WALANT can be used in fracture repair to allow access to surgery to a broader population, such as in Malaysia and leprosy surgery in India.</li> <li>Opens availability in operating rooms and anesthesiologist availability if done in a procedure room versus operating room.</li> </ul>
19	Löw et al, 2013 <sup>23</sup> (Germany)	Retrospective cohort	III	To compare workflow and operating room time of WALANT CTR versus axillary block CTR.	<p>When using WALANT CTR versus CTR under axillary block:</p> <ul style="list-style-type: none"> <li>The first operation of the day began significantly earlier.</li> <li>Time between consecutive CTRs significantly shortened.</li> <li>Surgical time shortened significantly when residents performed the operation in WALANT vs sedation.</li> <li>No difference in surgical time when the hand surgeon performed the operation.</li> </ul>
20	Maliha et al, 2019 <sup>24</sup> (USA)	Retrospective cohort, cost analysis	III	Compare cost savings and efficiency of TFR performed under WALANT in a hospital procedure room, versus under either local anesthesia, MAC, LMA, or general ET intubation with tourniquet in the main operating room.	<ul style="list-style-type: none"> <li>Overall total cost of TFR was 77% lower in a procedure room under WALANT versus in main operating room.</li> <li>Turnover time between cases was significantly shorter in procedure room, decreasing total time per case by 35 minutes on average.</li> <li>Instrument tray in main operating room cost \$3,300, versus \$993 in the procedure room.</li> <li>Cost of time in main operating room was \$44 more expensive per minute because of excess personnel, leading to 1 TFR completed in the operating room being \$3,344.46 more expensive.</li> <li>No difference in intraoperative and postoperative complication rates between the 2 sites.</li> </ul>

(continued on next page)

Table (continued)

#	Article	Study Type	Level of Evidence	Purpose	Cost Savings
21	Nelson et al, 2010 <sup>25</sup> (Canada)	Retrospective cohort, multicenter	III	Compare clinical outcomes and costs of Dupuytren fasciectomy performed under WALANT technique versus under general anesthesia in Canada.	<ul style="list-style-type: none"> <li>Average cost in Canadian dollars for Dupuytren fasciectomy is \$36 under WALANT in the clinic setting, versus \$469 under general anesthesia in the main operating room.</li> </ul>
22	Nguyen et al, 2015 <sup>26</sup> (USA)	Retrospective cohort, Economic/ decision analysis	II	Used the National Survey of Ambulatory Surgery 2006 database to evaluate how perioperative care factors contribute to costs in CTR.	<ul style="list-style-type: none"> <li>CTRs performed in an ambulatory surgery center had lower mean charges compared with CTRs performed in the hospital operating room (\$2,309 vs \$2,868, respectively).</li> <li>At the author's institution, CTR in a procedure room costs \$899, versus \$3,359 in an operating room.</li> <li>Based on the costs at the author's institution, if 70% of all CTRs in the United States were performed in a procedure room instead of a hospital operating room, this could equate to \$450–\$560 million in health care savings per year.</li> </ul>
23	Rhee et al, 2017 <sup>27</sup> (USA)	Prospective cohort, Economic/ decision analysis	IV	A prospective cohort study was performed on the first 100 consecutive, clinic-based WALANT hand surgery procedures performed at a military medical center from January 2014 to September 2015 by a single hand surgeon, and a cost analysis was performed.	<ul style="list-style-type: none"> <li>There were 85%, 84% and 70% cost savings with CTR, de Quervain, and TFR, respectively, by having the procedures performed in clinic under WALANT compared with the main operating room.</li> <li>During the study period, CTR, A1 pulley release, and de Quervain release performed in the clinic instead of the operating room amounted to \$393,100 in cost savings for the military health system.</li> </ul>
24	Thiel et al, 2019 <sup>28</sup> (USA)	Prospective cohort	II	Analyzed the use of a "minimal," custom pack of disposable surgical supplies for small hand surgery procedures, and then measured the waste from 178 small hand surgeries performed using either the minimal pack or the standard pack, depending on physician pack choice, in WALANT cases. Then, measured the cost differences and waste savings.	<ul style="list-style-type: none"> <li>Implementing green hand packs concomitantly with WALANT surgery halved surgical material costs and reduced surgical waste by 13% in wide-awake hand surgery in the ambulatory surgical setting, with use of local anesthesia and custom minimized hand packs, compared with sedation, local anesthesia, and standard hand packs in the hospital setting.</li> </ul>
25	Tang et al, 2019 <sup>29</sup> (China, Turkey, Switzerland)	Personal observation	V	Summarize the impacts of WALANT hand surgery on costs in different countries.	<p>China</p> <ul style="list-style-type: none"> <li>Total surgery cost of CTR under WALANT is 66% lower than the cost of CTR under brachial plexus block without sedation.</li> <li>Total operating room time is decreased by 33% in WALANT CTR.</li> </ul> <p>Switzerland</p> <ul style="list-style-type: none"> <li>Hand surgery performed under WALANT resulted in a 49% decrease in the overall surgery cost compared to standard anesthesia in a main operating room.</li> <li>29 WALANT hand surgery cases saved the equivalent of about \$36,000 in anesthesia, surgery, operating room, staff, and supply costs.</li> </ul>
26	Van Demark et al, 2018 <sup>30</sup> (USA)	Personal observation, Case series	V	Collected waste reduction and cost savings data while using a "Lean and Green" strategy and WALANT together.	<ul style="list-style-type: none"> <li>Cost savings of \$10.64 and 2.3 kg of waste per case, using WALANT with field sterility and compact, "green" packs. The institution saved \$13,250.42, and waste production decreased by 2.5 metric tons over 2 years.</li> <li>The authors estimated a nationwide savings of \$2.13 million and waste reduction of 459 metric tons if all 2,000 hand surgeons in the country were to perform 100 "green" cases a year.</li> </ul>

CAD, Canadian dollars; CPT, Current Procedural Terminology; CRIF, closed reduction internal fixation; CTS, carpal tunnel syndrome; ET, endotracheal; HIPAA, Health Insurance Portability and Accountability Act; LMA, laryngeal mask airway; PACU, postanesthesia care unit.

undergoing WALANT hand surgery have even been reported to have lower preoperative anxiety compared with patients undergoing hand surgery with general anesthesia.<sup>32</sup>

### Surgery Setting and Anesthesia Services

Surgery performed with WALANT obviates the intraoperative requirement of an anesthesia provider, thereby eliminating anesthesia costs incurred by the patient.<sup>6,7</sup> Foster et al<sup>8</sup> used a national insurance database to investigate CTR costs based on anesthesia type, and found that total hospital costs for CTR performed with general or regional anesthesia were \$654 more expensive than those performed with WALANT. Similarly, Alter et al<sup>10</sup> estimated that WALANT hand surgery patients saved from \$139 to \$432 in anesthesia costs compared with the patients with the same surgery performed under intravenous sedation.

Not requiring intraoperative anesthesia personnel allows for WALANT surgery to be performed in settings other than a main operating room, such as in ambulatory surgery centers or in office or clinic procedure rooms. Studies have consistently shown that hand surgery performed in an outpatient surgery center (OSC) or in a clinic setting are much more cost and time efficient than those performed in a main operating room.<sup>14,15,22,24,27</sup> Nguyen et al<sup>26</sup> performed an analysis of CTR charges using the 2006 National Survey of Ambulatory Surgeries database. Comparing 160,000 CTRs performed in an ambulatory surgical center versus in a main operating room with any anesthesia type, the surgical setting was the variable most strongly associated with the total procedural charges. Specifically, CTRs performed in an ambulatory surgery center were associated with lower mean total charges compared with those performed in a main operating room (\$2,309 vs \$2,868, respectively). However, this database did not include data on CTRs



performed in office or clinic procedure rooms. Nguyen et al<sup>26</sup> noted that CTR costs at their institution were \$899 in a procedure room versus \$3,359 in the main operating room. Based on these costs, the authors estimated that if 70% of nationwide CTRs could be performed in a procedure room instead of an operating room, this could result in \$450 to \$560 million in health care savings per year.

In patients undergoing trigger finger release (TFR) in a procedure room with WALANT versus in a main operating room with a mix of anesthesia and sedation types, Maliha et al<sup>24</sup> found that TFRs performed in a procedure room saved \$3,344.46 per case compared with those performed in a main operating room, a cost decrease of 77%. Much of these cost savings were attributed to the decreased operating room personnel service costs in a procedure room, which were \$44 less per minute compared with the costs of surgery in a main operating room. The authors also found that the cost of supplies in the main operating room was over triple the amount that was required for the same case performed in a procedure room (\$3,304.25 vs \$993.79, respectively). Turnover time in the procedure room was significantly shorter than that in a main operating room, saving an average of about 35 minutes per case ( $P < .001$ ). Studies outside the United States have reported similar findings. In Canada, Leblanc et al<sup>22</sup> found that the cost of WALANT CTR performed in a main operating room was nearly 4 times that of WALANT CTR in the clinic setting. Gillis and Williams<sup>18</sup> similarly reported a 4-fold increase in costs for closed reduction internal fixation of hand fractures when performed in the main operating room with WALANT versus in an ambulatory surgical setting with WALANT.

The cost-saving effects of performing hand and upper-extremity surgery in ambulatory settings appear to compound when also using the WALANT technique over traditional anesthesia.<sup>14,15,22,24,27</sup> Carr et al<sup>14</sup> performed a direct-cost analysis of a single surgeon performing open CTR in the main operating room with monitored anesthesia care (MAC; operating room-MAC group), OSC with MAC (OSC-MAC group), OSC with WALANT (OSC-local group), and clinic with WALANT (clinic-WALANT group). The average direct costs per surgery were \$213.75 in the operating room-MAC group, \$102.79 in the OSC-MAC group, \$55.66 in the OSC-local group, and \$31.71 in the clinic-WALANT group, with the clinic being significantly more cost effective than any other setting ( $P < .005$ ). Additionally, their analysis revealed that in the same OSC setting, CTR with WALANT had almost half the direct costs as when performed with MAC. Chatterjee et al<sup>15</sup> performed a cost analysis evaluating both open and endoscopic CTRs performed in the main operating room with traditional anesthesia providers versus in a clinic procedure room with WALANT, and found that both procedures were more expensive and less efficient when performed in a main operating room. At their institution, total costs for an open CTR were \$670 in the clinic versus \$3,469 in the main operating room, and total costs for endoscopic CTR were \$985 in the clinic versus \$2,273 in the main operating room. When taking into account the opportunity costs per CTR performed in the operating room instead of in the clinic, the authors concluded that open CTRs performed in the main operating room resulted in a true net loss of \$3,349 per CTR, and endoscopic CTRs performed in the main operating room resulted in a true net loss of \$1,562 per CTR. In a prospective cohort study of 100 consecutive WALANT hand surgery patients at a military medical center, Rhee et al<sup>27</sup> reported cost savings of 85% for CTR and 70% for TFR when performed in a clinic with WALANT compared to in the main operating room with intravenous-sedation anesthesia.<sup>33</sup> In <2 years of starting to use WALANT hand surgery in the clinic, the authors reported a total of \$393,100 in cost savings to the Military Health Care System.

### Time Efficiency

The ability to perform WALANT hand surgery in OSCs and in the clinic setting results in decreased surgical time, room turnover

time, and time spent in the postanesthesia care unit.<sup>12,13,15,18,22</sup> Several studies have found that these time savings and increased efficiency with WALANT directly result in cost savings compared with surgery performed in the operating room under general anesthesia.<sup>22,24–28,33,34</sup> Caggiano et al<sup>12</sup> retrospectively evaluated the nonsurgical operating room times of elective hand surgery performed with WALANT versus with MAC/local anesthesia or with general anesthesia, all performed in a main operating room. They found that surgery performed with WALANT resulted in significantly shorter room turnover time, in-room presurgical time, in-room postsurgical time, and total nonsurgical time per case than cases performed with MAC/local anesthesia or with general anesthesia ( $P < .05$ ). Specifically, the total nonsurgical time was reduced by 40% when surgery was performed with WALANT versus with general anesthesia.

Leblanc et al<sup>22</sup> conducted a retrospective cost analysis comparing the costs of WALANT CTR performed in the main operating room versus in the office or clinic settings in Canada. The authors found that in 3 hours, 9 WALANT CTRs can be performed in an ambulatory setting, versus only 4 WALANT CTRs being performed in the main operating room in the same time period. Similarly, Chatterjee et al<sup>15</sup> estimated that in the same amount of surgical block time, twice as many CTRs could be completed in the clinic setting versus in a main operating room. They noted this increased efficiency was because of a multitude of factors, including the decreased room turnover time, the decreased patient transport time, and no required preoperative anesthesia preparation time. Lastly, Gillis and Williams<sup>18</sup> reported being able to perform 8 closed reduction internal fixations for hand fractures in the ambulatory surgical setting, versus only 5 in the main operating room within the same 8-hour surgical block.

### Open Versus Endoscopic CTR

The decision to perform a WALANT open versus endoscopic CTR can affect the costs and environmental impacts of the WALANT technique. Several studies have found that WALANT open CTRs can be more cost effective than WALANT endoscopic CTRs.<sup>8,15</sup> In a national-database cost analysis, Foster et al<sup>8</sup> found endoscopic CTR to be \$794 more expensive than open CTR, and found CTR with general or regional anesthesia to be \$654 more expensive than CTR with WALANT. The authors estimated that widespread adoption of WALANT for CTR would amount to \$2.3 billion in health care savings over the next decade. Additionally, if these procedures were performed open instead of endoscopic, these savings would increase to \$3.6 billion in the next decade, while reducing operating room waste. Lastly, the high energy consumption of the endoscopic equipment generally results in endoscopic and arthroscopic surgeries having larger carbon footprints than open surgeries.<sup>3</sup>

### Operating Room Waste Reduction

The WALANT technique provides the opportunity to cut operating room waste while simultaneously increasing cost savings for the surgical facility, benefiting both the health care system and the environment. Hand surgery performed with WALANT requires fewer operating room materials and equipment, and allows the surgery to be performed in more efficient surgical settings, both of which result in less operating room waste.<sup>9,13,28,30</sup>

Using leaner surgical packs is a relatively simple and efficient way to save procedural costs and reduce operating room waste. Prompted by the “Lean and Green” hand surgery initiative of the American Association for Hand Surgery, Van Demark et al<sup>35</sup> began performing WALANT hand surgery with “green packs,” which minimized both the materials in prepackaged surgical packs and

the instruments used, and under “minor field sterility,” without surgical gowns or antibiotics.<sup>30</sup> These changes resulted in cost savings of \$10.64 per case and waste reduction of 2.3 kg per case. After 1,099 WALANT hand surgeries were performed over 2 years with these “green packs,” the total facility cost savings totaled \$13,250, and the amount of operating room waste decreased by 2.5 metric tons. The authors estimated that if all 2,000 hand surgeons in the United States used these “Lean and Green” techniques for 100 cases per year, the nationwide cost savings could total \$2.13 million and waste reduction could total 459 metric tons of operating room waste.<sup>30,35</sup>

Other authors have slimmed down prepackaged surgical packs and have consistently found this initiative to result in overall cost savings for the facility.<sup>9,28</sup> Albert and Rothkopf<sup>9</sup> were able to eliminate 7 items from prepackaged hand surgery packs, which they estimated could result in \$17,381 of yearly cost savings across their institution. Similarly, Thiel et al<sup>28</sup> reduced the contents of their WALANT hand surgical pack, and observed a 13% reduction in operating waste per case and a 55% decrease in supply costs per case compared with their original, standard hand pack. It is worth noting that many of these operative equipment–limiting interventions could be, and are encouraged to be, used in hand surgery practice regardless of the anesthesia type used.

Performing WALANT hand surgery in an OSC or clinic setting versus in a traditional operating room is also an effective way to decrease operating room waste. Carr et al<sup>14</sup> prospectively compared the total weight of operating room waste in those 3 surgical settings, and found that a CTR performed in a hospital operating room with MAC produced more waste (4.78 kg) per case than a CTR performed with WALANT in either the OSC (2.60 kg) or the clinic setting (0.65 kg). The clinic setting produced statistically significant less operating room waste compared with the other 2 settings ( $P < .005$ ). The authors noted that much of this waste mass reduction was achieved by using reusable towels for draping, and by eliminating surgical gowns via the “minor field sterility” technique previously mentioned.

### Immediate Postoperative Period

Several studies have demonstrated that there is a considerable increase in time spent in the postoperative recovery room following surgery with sedation versus with local anesthesia, which results in increased staff and medication costs.<sup>10,13,16,17,19</sup> Codding et al<sup>16</sup> performed a retrospective review analyzing consecutive cases of single TFR with MAC versus with WALANT, with all surgeries being performed in the same manner, at the same facility, and by the same surgeon. Their results demonstrated that the average postanesthesia care unit time for the MAC group was 62.9 minutes (range, 45–101 minutes), versus 30.2 minutes (range, 15–55 minutes;  $P < .01$ ) for the WALANT group. Davison et al<sup>17</sup> performed a prospective cohort analysis of 100 consecutive WALANT CTRs in Canada compared with 100 consecutive CTRs with intravenous sedation in Iowa and found that WALANT patients spent on average 1.4 hours less in the hospital following surgery. As mentioned previously, WALANT surgery in theory eliminates the need for an escort after surgery, increasing convenience for the patient and saving time and potential lost wages for the third party.

Several studies have reported an increased need for medications, including narcotics, after surgery amongst patients who receive sedation for surgery.<sup>36,37</sup> Davison et al<sup>17</sup> investigated postoperative narcotic use among patients undergoing WALANT versus general anesthesia hand surgery, and reported postoperative narcotic use of 5% by WALANT patients versus of 67% by sedated patients ( $P < .001$ ). However, this discrepancy could have been influenced by both cultural bias and health care system differences,

as the WALANT group was studied in Canada and the sedated group was studied in Iowa.

The postoperative follow-up period may also be potentially improved for WALANT patients. Hand surgery with WALANT allows active participation in surgery, which could lead to improved recovery; decreased complications, such as stiffness; decreased occupational therapy visits; decreased postoperative office visits; and fewer revision surgeries.<sup>7,10,22,27</sup>

This review of the current literature provides a thorough examination of the WALANT technique’s costs and environmental impacts in hand surgery. These effects span the preoperative, intraoperative, and postoperative periods, and WALANT hand surgery has consistently been shown to be more cost effective and environmentally friendly than traditional hand surgery with sedation. Further validating the WALANT technique’s versatility are the many studies included in this current review that represent a wide variety of health care and economic systems, both nationally and internationally, all demonstrating similar findings regarding the WALANT technique’s positive economic and environmental impacts. With the increasing shift of orthopedic surgery reimbursement to value-based plans, such as bundled payments, it is imperative that hand surgeons and medical facilities promote cost containment as much as possible.<sup>38,39</sup> By using cost-saving measures, such as the WALANT technique in hand surgery, surgeons can contribute to reducing the national health care economic burden while continuing to provide high-level patient care.

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