Regional Anesthetic Blocks for Donor Site Pain in Burn Patients: A Meta-Analysis on Efficacy, Outcomes, and Cost

Les blocs anesthésiques régionaux pour soulager la douleur aux sites donneur chez les patients brûlés : une méta-analyse de l'efficacité, des résultats cliniques et des coûts

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Abstract

Background: Skin graft donor site pain significantly affects pain management, narcotic use, and hospital length of stay. This study is intended to evaluate the efficacy of regional anesthesia in the burn population to decrease narcotic consumption and to assess the impact on hospitalization costs. **Methods:** PubMed/MEDLINE, Embase, and ScienceDirect were searched with the following inclusion criteria: comparative studies, adult populations, burn patients, autologous skin grafting, regional nerve blocks, and traditional narcotic regimens. Outcomes assessed included narcotic consumption, pain scores, and opioid side effects. Meta-analysis obtained pooled values for morphine consumption and side effects. Cost analysis was performed using published data in the literature. **Results:** Final analysis included 101 patients. Cumulative morphine consumption at 72 hours was lower for patients treated with regional anesthesia versus patient-controlled analgesia (PCA; single shot 25 ± 12 mg, continuous regional 23 ± 16 mg, control 91.5 ± 24.5 mg; $P < .05$). Regional anesthesia decreased nausea/vomiting ($P < .05$) and lowered subjective pain scores. Regional anesthesia interventions cost less than PCA, single shot less than continuous ($P < .05$). **Conclusion:** Regional anesthesia at skin graft donor sites significantly decreases narcotic consumption in burn patients. Regional anesthesia is cost-effective, decreases side effects, and may result in shorter hospital stays due to improved pain management.

Résumé

Historique : La douleur aux sites donneur des greffes de peau a une influence importante sur la gestion de la douleur, la consommation de narcotiques et la durée de l'hospitalisation. La présente étude vise à évaluer l'efficacité de l'anesthésie régionale au sein de la population de brûlés pour réduire la consommation de narcotiques et à en examiner les effets sur les coûts d'hospitalisation. **Méthodologie :** Les chercheurs ont utilisé les critères d'inclusion suivants pour effectuer leurs recherches dans PubMed/MEDLINE, Embase et ScienceDirect : études comparatives, populations adultes, patients brûlés, greffes de peau autologues, blocs nerveux régionaux et posologies classiques de narcotiques. La consommation de narcotiques, les scores de douleur et les effets secondaires des opioïdes étaient les résultats secondaires évalués. La méta-analyse a donné des valeurs groupées de consommation et d'effets secondaires de morphine. L'analyse des coûts a été exécutée au moyen des données publiées. **Résultats :** L'analyse finale incluait 101 patients. La consommation cumulative de morphine au bout de 72 heures était plus faible chez les patients traités par anesthésie régionale que chez ceux qui contrôlaient leur propre analgésie (une seule infusion 25 ± 12 mg, infusion régionale continue 23 ± 16 mg, sujets témoins $91,5 \pm 24,5$ mg; $p < 0,05$). L'anesthésie régionale réduisait les nausées et les vomissements ($p < 0,05$), de même que les scores de douleur subjective. L'anesthésie régionale est moins

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coûteuse que celle contrôlée par le patient, et une seule infusion, moins chère qu'une infusion continue ($p < 0,05$). **Conclusion :** L'anesthésie régionale aux sites donneur des greffes de peau réduit considérablement la consommation de narcotiques chez les patients brûlés. L'anesthésie régionale est économique, réduit les effets secondaires et peut raccourcir le séjour hospitalier grâce à une meilleure gestion de la douleur.

Keywords

split-thickness skin graft, donor site, regional anesthesia, narcotic, consumption, cost analysis, burn

Introduction

The optimal management of skin graft donor site-associated pain remains a significant challenge in the clinical care of patients after burn-related injuries. Burns significant enough to require autologous skin grafts often require multimodal pain management. Strategies to optimize pain control after skin graft harvest may decrease total narcotic use and therefore lead to shorter hospitalizations and decrease costs in patients requiring skin grafts.^{1,2} The use of regional nerve blocks in conjunction with narcotic use is an increasingly popular adjunct approach for pain management in the burn population. Regional nerve blocks have been shown to improve pain scores, decrease narcotic consumption, and shorten hospital stays in the orthopedic literature.³⁻⁶

The current indications for regional anesthesia in burn skin graft donor site analgesia remain understudied. The purpose of this study is to answer the following clinical question: “when compared to donor sites treated without regional anesthesia techniques, do burn skin graft donor sites treated with regional anesthesia have improved pain scores and lower overall treatment costs?” We hypothesize that regional anesthesia will significantly decrease pain and total patient-related costs when compared to nonregional analgesic management of donor sites. Our specific aims are to (1) identify a cohort of patients undergoing burn skin graft donor site treatment with and without regional anesthesia, (2) evaluate the pain scores and pain control for each group, and (3) compare the cost of total treatment between the 2 groups.

Materials and Methods

Reporting Methodology

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria were used to organize the search of databases.⁷

Literature Search

The research team independently performed the literature search to identify studies regarding regional anesthesia in burn patients undergoing autologous skin graft procedures. PubMed/MEDLINE, Embase, and ScienceDirect databases were searched through July 2017 with the following key words: “regional anesthesia,” “regional block,” “nerve block,” “local anesthesia,” “peripheral nerve,” “burn,” “skin graft,” and “donor site.” The MeSH terms and entry terms related to the

key words were also used in this comprehensive literature search. Titles and abstracts of potential articles for inclusion were independently examined. Full-text articles were retrieved and examined when their titles and abstracts did not provide enough information for a definite decision. “Burn” as a search term was excluded, and literature search was repeated to ensure no studies were missed.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) the design was a comparative study published in the English-language literature, (2) study participants were adult patients (>18 years of age) with burn injuries who underwent split-thickness skin grafts (3) and received regional anesthesia, (4) the control group was standard of practice for post-operative pain management, and (5) the study reported total narcotic consumption, pain scales, and complications. Exclusion criteria included the following: non-English language literature, noncomparative studies or case series, abstract-only, solely pediatric population, no use of regional anesthesia, and no use of narcotics in the postoperative control group.

Methodological Quality Assessment

Methodological Index for Non-Randomized Studies (MINORS) guidelines was used to assess the methodological quality of the included studies.⁸ Scores >16 were considered adequate. Seven full-text articles were evaluated for eligibility, of which 3 met inclusion criteria and appropriate methodological quality.⁹⁻¹⁵ Of the studies evaluated, one was ultimately excluded on the basis of outcomes, as no narcotics were used in the control group.¹⁵

Primary/Secondary Predictor Variable and Outcomes

The primary predictor variable was the presence or absence of regional anesthesia in each study. Secondary predictor variables were factors potentially associated with burn injury. These factors included gender (male versus female), age (years) at the time of surgery, percentage total body surface area (%TBSA), and duration of anesthesia. Outcomes measured included narcotic consumption, pain, and narcotic or regional anesthesia side effects as well as costs related to pain management with or without regional anesthesia. No study reported length of hospitalization. Cost data were extrapolated using contemporary data published in the literature.

Data Extraction

The research team extracted data for study details (design, first author, year of publication), demographics and patient descriptive statistics, number of patients in each study group, details of regional anesthesia, and outcome measures.

Statistical Analysis

Data sets were entered into a statistical database (SPSS v.22.0; SPSS Inc) for analysis. Descriptive statistics were computed to provide an overview of the sample. Bivariate statistics were computed to identify associations between the predictor variables and outcome variables. Given the lack of confirmed normality within the data set, nonparametric methods were used for bivariate comparisons. For all analyses, a P value <0.05 was considered statistically significant.

Results

Over the study period, 3 analgesic treatments were identified in 101 participants.^{10,11} All participants were included; no participants were excluded due to incomplete follow-up data. Thirty-seven patients (36.6%) were treated without analgesic blocks and were classified into group 1 or the control group; 64 (63.4%) patients were treated using analgesic blocks and were classified as group 2, of which 37 had continuous regional anesthesia and 27 had single-shot regional anesthesia. The fascia iliaca compartment block was used for all regional anesthesia blocks. Sixty-five (65.6%) patients were males, 36 (38.6%) were females. The sample's mean age was 39 ± 15 years. The duration of clinical follow-up was 3 days. The cumulative morphine consumption on post-operative day (POD) 3 for group 1 was 91.5 ± 24.5 mg, 25 ± 12 mg for single shot, and 23 ± 16 mg for continuous, $P = .00$ using analysis of variance. Visual analog scale (VAS) pain scores were significantly improved for both groups of regional anesthesia, compared to controls, $P < .01$ per reporting of the individual studies. The presumed calculated cost of intervention for group 1 was 98 dollars/day for morphine patient-controlled analgesia (PCA), 49.85 dollars for single-shot regional anesthesia, and 82.59 dollars/day for continuous regional anesthesia (Figure 1). Using Wilcoxon signed-rank test for nonparametric data, it was determined these costs were significantly different ($P < .05$).

The search and retrieval results are summarized in Figure 2. Characteristics of interventions, differences in demographics, and main points of each study are summarized in Table 1A and reflect comparable groups for age, gender, %TBSA, and duration of anesthesia. Specific pooled demographic data were analyzed in Table 1B.

Cumulative Morphine Consumption

The continuous and single-shot regional anesthesia cohorts both had statically significant lower total morphine consumption compared to the control group (Table 2). The control group consumed a cumulative amount of 91.5 mg on average over 72

hours, while the continuous group consumption was 23 mg on average, and the single shot was 25 mg on average ($P = .00$). There was no statistical difference in the morphine consumption between the continuous regional blockade and the single-shot approach.

Visual Analog Scale: Pain

Due to the nature of reported data, meta-analysis was not possible for the VAS pain data. Two trends were appreciated on review of the studies included. First, the continuous regional anesthesia group experienced improved analgesia compared to PCA alone at the time of donor site dressing change on POD3 (Table 3A). Second, regional anesthesia appears to decrease pain during hip flexion and dynamic movement compared to PCA alone (Tables 3B and 3C). Static pain scores were not significantly different between continuous, single-shot, and control groups.^{10,11}

Narcotic Side Effects

Of the side effects measured between the studies, meta-analysis was possible for nausea/vomiting, pruritus, and local anesthetic toxicity (Table 4). In both studies, continuous blockade resulted in unilateral lower extremity muscle weakness for a few of the cohort. There was a statistically significant decrease in nausea and vomiting in both regional anesthesia groups compared to control ($P = .00$). There was no statistically significant difference in pruritus ($P = .79$). No patients experienced local anesthetic toxicity.

Discussion

Regional anesthesia skin graft donor site pain management remains understudied and underutilized. The aim of this study was to evaluate the efficacy of regional anesthesia during burn reconstruction to decrease pain and patient-related costs. We hypothesized that regional anesthesia would significantly decrease pain and narcotic consumption, as well as decrease total hospital costs compared to nonregional pain management. While other studies have evaluated local anesthetic adjuncts such as topical numbing cream (eg, Emla) or tumescent solution prior to graft harvest,^{9,12,13,16} and several have evaluated efficacy of various regional blocks in case series,^{17,18} this is the first meta-analysis using comparative studies to consider regional anesthesia for prolonged post-graft donor site pain.

After thorough evaluation, 2 studies met criteria for inclusion.^{10,11} All studies harvested skin grafts from the lateral thigh. Regional anesthesia was achieved with the fascia iliaca compartment block, a variant of the "3 in 1" femoral block, providing sensory blockade to the cutaneous lateral femoral and femoral nerves. Meta-analysis indicated that regional anesthesia decreased total narcotic consumption and narcotic side effects compared to the control groups. The VAS pain scores trended lower in the regional anesthesia groups

Figure 1. Regional anesthesia calculations. *500 mL pump is equivalent to continuous infusion rate of 10.4 mL/d over 48 hours.

according to review of the individual studies, especially in dynamic movement.

While neither morphine nor ropivacaine is benign, narcotic use is associated with nausea, vomiting, constipation, and pruritus, while long-term narcotic use is associated with dependence. Narcotic use also presents concerns in patients with depressed respiratory drive, such as sleep apnea. Furthermore, there is possible development of acute tolerance, and it has been documented that burn patients also suffer opioid-induced hyperalgesia.¹ Burn injuries are known to produce severe pain,² predisposing burn patients to a much higher rate

of narcotic consumption during hospitalization. Decreasing narcotic consumption is a reasonable goal in pursuing regional anesthesia. Complications associated with regional anesthesia include anesthetic toxicity, temporary muscle weakness, and catheter-associated infection for continuous local anesthesia.^{10,11}

It would be prudent to assess whether regional anesthesia can offset the duration of hospitalization due to superior analgesia. The average hospitalization for a patient with a mean burn size of 8.8% to 12.3% TBSA burn costs US\$4656 ± US\$5309 per day based on national data collected by

Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) search and retrieval results.

Kastenmeier et al, consistent with the American Burn Association average of US\$5500 for surviving patients.^{19,20} The mean length of stay for 10% average TBSA was 14 days according to one study,²¹ while others listed averages of 4 to 9 days for burn patients <20% TBSA, including those treated with skin grafts.^{16,19} Most recently, it has been suggested that each %TBSA burned adds 1.0 to 1.5 days to the hospitalization.²⁰

Patient-controlled analgesia with morphine is often the nonregional analgesic of choice for capable patients. Morphine itself is an inexpensive drug, with an average cost of US\$16 per 30 mg/30 mL compared to US\$21 for a 6 mg/30

mL syringe of hydromorphone.²² While few studies look at the cost of morphine and PCA in burn or skin graft patients, Palmer et al evaluated the first 48 hours post-operatively for total knee arthroplasty (TKA), total hip arthroplasty (THA), and abdominal surgery and estimated that the number of syringes of morphine used ranged from 1.9 to 2.5, while hydromorphone ranged from 3.2 to 4.2. Aggregating the cost of PCA pump, nursing setup, intravenous tubing, saline, and morphine or hydromorphone, this same study established that the total cost of equipment and opioid drugs ranged US\$196 to US\$243 for TKA, THA, or abdominal

Table 1A. Characteristics of Interventions, Outcomes, and Demographic Data.

Author, year	Study type	Regional anesthesia		Standard narcotic regimen		Demographic difference between 2 groups	Key results	MINORS score
		n	Block	n	Regimen			
Cuignet et al, 2004 ¹¹	Prospective, double-blind randomized control trial	10	Fascia iliaca compartment block = via femoral catheter, bolus 40 mL ropivacaine 0.2%, then continuous infusion 10 mL/h ropivacaine 0.2% and morphine PCA and propacetamol 2 g IV every 6 hours	10	Femoral catheter: bolus 40 mL saline 0.9%, then 10 mL/h continuous saline 0.9% and morphine PCA and propacetamol 2 g IV every 6 hours	None (age, gender, TBSA, excision site, duration of anesthesia, time between burn and surgery) Data collected: not stated, however Cuignet et al, 2005, ¹⁰ stated Cuignet et al, 2004, ¹¹ to be separate study population	<ul style="list-style-type: none"> Cumulative morphine requirements significantly less in the study group compared to the control ($P < .01$) Donor site VAS pain scores trended lower in the study group over 72 hours VAS pain scores at 1st dressing change lower in the study group ($P < .05$) Opioid-related side effects data limited by lack of power (post hoc analysis) Pain-free hip flexion improved faster in the study group ($P < .05$) on post-operative day 1 compared to control 	21/24
Cuignet et al, 2005 ¹⁰	Prospective, double-blind randomized control trial	27	Fascia iliaca compartment block = via femoral catheter, 40 mL bolus ropivacaine 0.2% and 10 mL/h continuous infusion ropivacaine 0.2% and morphine PCA and propacetamol 2 g IV every 6 hours	27	Femoral catheter: bolus 40 mL saline 0.9%, then 10 mL/h continuous saline 0.9% and morphine PCA and propacetamol 2 g IV every 6 hours	None (age, gender, TBSA, excision site, anesthetic technique, duration of anesthesia, time between burn and surgery) Data collected: September 2001-2003	<ul style="list-style-type: none"> Cumulative morphine requirements significantly less in 2 study groups compared to control ($P < .01$) Dynamic VAS donor site pain scores were significantly lower in both study groups compared to control at 24, 48 and 72 hours ($P < .01$) VAS pain scores at dressing change were highest in control, then the single-shot vs the continuous infusion group ($P < .01$) Opioid side effects: nausea and vomiting were lower in the 2 study groups vs control ($P < .0167$) 	24/24
		27	Fascia iliaca compartment block = via femoral catheter, 40 mL bolus ropivacaine 0.2% and 10 mL/h saline 0.9% and morphine PCA and propacetamol 2 g IV every 6 hours					

(continued)

Table 1A. (continued)

Author, year	Study type	Regional anesthesia		Standard narcotic regimen		Demographic difference between 2 groups	Key results	MINORS score
		n	Block	n	Regimen			
							<ul style="list-style-type: none"> Continuous infusion group experienced muscle weakness (Bromage score = 2, inability to lift thigh against resistance), compared to single-shot and control groups ($P < .01$) 	

Abbreviations: IV, intravenous; MINORS, Methodological Index for Non-Randomized Studies; PCA, patient-controlled analgesia; TBSA, total body surface area; VAS, visual analog scale.

^aPatient-controlled analgesia settings were consistent for both studies by Cuignet et al: morphine chlorhydrate 2 mg/mL, 1 mg bolus with lockout interval of 5 minutes, maximum dose 25 mg/h, and supplemented by 1 mg IV morphine boluses driven by VAS scores >4.

Table 1B. Pooled Demographic Data.

Variable	Continuous regional anesthesia	Single-shot regional anesthesia	Nonregional analgesia (control)	P value
Sample size (n)	37	27	37	Not applicable
Average age (years $\pm$ SD)	41 $\pm$ 14.5	38 $\pm$ 15	38 $\pm$ 15.5	.63
Gender (male)	25 (67.56%)	17 (62.96%)	23 (62.16%)	.88 ^a
Average TBSA % $\pm$ SD	18% $\pm$ 13.5%	15% $\pm$ 11%	14% $\pm$ 7.5%	.27
Average duration of anesthesia (minutes $\pm$ SD)	84.5 $\pm$ 12	84 $\pm$ 12	86.5 $\pm$ 14	.70
Average time from burn to surgery (days $\pm$ SD)	19 $\pm$ 7	18 $\pm$ 8	16 $\pm$ 7.5	.22

Abbreviation: TBSA, total body surface area.

^aChi-square test performed.

Table 2. Cumulative Morphine Requirements.

Post-operative day (POD)	Continuous regional anesthesia, average morphine/day (mg) $\pm$ SD	Single-shot regional anesthesia, average morphine/day (mg) $\pm$ SD	Nonregional analgesia (control), average morphine/day (mg) $\pm$ SD	P value
POD0	6.5 $\pm$ 3.5	6 $\pm$ 3	20.5 $\pm$ 8	
POD1	11 $\pm$ 6.5	11 $\pm$ 6	44.5 $\pm$ 14.5	
POD2	16.5 $\pm$ 9.5	19 $\pm$ 9	74 $\pm$ 21.5	
POD3	23 $\pm$ 16	25 $\pm$ 12	91.5 $\pm$ 24.5	.00 ^a

^aAnalysis of variance performed.

Table 3A. Donor Site VAS Pain Scores.^a

Post-operative day (POD)	Continuous regional anesthesia, median VAS score [interquartile range]	Nonregional analgesia, median VAS score [interquartile range]	P value
POD1	0 [1.5]	3.5 [1.0]	
POD2	0 [2.25]	3 [3.25]	
POD3 ^b	3 [1.0]	7 [3]	<.01

Abbreviation: VAS, visual analog scale.

^aData extrapolated from figures found in Cuignet et al.¹¹

^bDuring dressing change.

surgery over 48 hours post-operatively, roughly US\$98 to US\$121.50 per day.²²

If it can be proven that the cost of the block is offset by shorter hospitalization, then regional anesthesia would be superior not only in efficacy but also cost-efficiency. The

average duration of a femoral nerve block procedure for Hunt et al was 86 $\pm$ 38 seconds.²³ Operating room costs, whether performing the block in the operating room itself or post-operative recovery unit, remain a complex topic. In one study, the estimated operating room cost, per extra minute, at an academic medical center was US\$9.57, while other studies

Table 3B. Pain-Free Hip Flexion.^{a,b}

Post-operative day (POD)	Continuous regional anesthesia, pain-free hip flexion % $\pm$ SD	Nonregional analgesia, pain-free hip flexion % $\pm$ SD	P value
POD1	97% $\pm$ 22%	68% $\pm$ 16%	Not provided in study
POD2	109% $\pm$ 19%	79% $\pm$ 18%	Not provided in study

^aData extrapolated from figures found in Cuignet et al.¹¹^bNormalized to presurgical baseline.**Table 3C.** Dynamic VAS Pain Scores.^a

Post-operative day (POD)	Continuous regional anesthesia, median VAS score [interquartile range]	Single-shot regional anesthesia, median VAS score [interquartile range]	Nonregional analgesia, median VAS score [interquartile range]	P value
POD1	1 [1]	3 [2]	5 [2]	Continuous and single vs control, <.01
POD2	2 [2]	3 [1]	5 [3]	Continuous and single vs control, <.01
POD3	2 [2]	3 [1]	6 [3]	Continuous and single vs control, <.01
POD3 ^b	3 [2]	6 [1]	7 [2]	Control and single vs continuous, <.01

Abbreviation: VAS, visual analog scale.

^aData extrapolated from figures found in Cuignet et al.¹⁰^bDuring dressing change.

state base costs of US\$15 to US\$20 per minute (excluding physician costs) and yet other studies note costs ranging from US\$22 to US\$133.^{24,25} In general, ultrasound costs range from US\$8000 to US\$25 000 for 2009 to 2010 compact and handheld models.²⁶ Per Ponde et al, an ultrasound purchase could be amortized in 3 years in some high-use departments.²⁷

Continuous versus single-shot regional anesthesia were shown to be comparable for the first 72 hours in this study, making it relevant to compare costs between interventions. For single blocks, ropivacaine 0.2% costs on average US\$4.29 for 20 mL (US\$0.10/mg) and bupivacaine 0.25% costs for 30 mL (US\$0.01/mg).²⁸ Injection needles, standard through nerve stimulating, cost US\$0.16 to US\$13.80 per unit. Costs for continuous catheter supplies (needles and catheters) range from US\$8.02 to US\$57.50, from introducing needles to stimulating

Table 4. Side Effects, by Treatment Group.

Variable	Continuous regional anesthesia	Single-shot regional anesthesia	Nonregional analgesia	P value
Sample size (n)	37	27	37	Not applicable
Nausea + vomiting, ^a n (%)	4 (10.8%)	1 (4%)	13 (35.1%)	.00 ^b
Pruritus, n (%)	24 (64.9%)	16 (59%)	25 (67.57%)	.79 ^c
Local anesthetic toxicity ^d	0	0	0	Not applicable

^aCuignet et al¹¹ separated variables nausea and vomiting; however, n = 0 for vomiting, and thus, data were combined to match data from Cuignet et al.¹⁰^bFisher exact test performed.^cChi-square test performed.^dMeasured through questioning: drowsiness, blurred vision, trouble hearing, metallic taste in mouth, fatigue.

needles; infusion pumps required to maintain analgesia vary from fixed basal rate pumps to variable/bolus pumps, US\$40 to US\$475 per unit. Furthermore, cost to fill infusion reservoirs with 500 mg costs US\$4/unit for bupivacaine and US\$40/unit for ropivacaine.²⁶ “3-in-1” femoral nerve blocks using ropivacaine 0.25%, ropivacaine 0.5%, and bupivacaine 0.25% were found to be comparable in analgesic effect for total knee replacement patients,³ suggesting the cheapest regional anesthetic could be selected for the blockade.

Limiting this evaluation of cost-efficiency is that the studies evaluated in this meta-analysis did not measure past the first dressing change at 72 hours, and therefore, data are inconclusive regarding regional blocks offsetting hospital length of stay. However, using these numbers in a case study, it would cost US\$98/day for morphine PCA,²² US\$49.85 for a single-shot regional block using ropivacaine, and US\$164.97 for a continuous block for an estimated 48 hours or US\$82.49/day (Figure 1 for estimation calculations). This suggests that single-shot regional blocks are cost-effective but does not take into account the cost of the morphine required to supplement the block nor significant variations in cost of operating room time to perform the block.

Furthermore, it is key to note that these regional anesthesia interventions can be billed for if they are not performed in the operating room but in the pre or post-anesthesia care unit and that a physician fee may be added depending on the institution. Current procedural terminology for these blocks would include such codes as CPT code 01991 for anesthesia for diagnostic or therapeutic nerve blocks and injections and CPT code 01996 for daily management by an anesthesia provider. Such charges for these codes vary, and preliminary data at our institution for these codes start with physician fees of US\$92 and can range up to US\$2286 billed, which would dramatically change the cost-effectiveness of these blocks for the system.

While the studies did not share the same patient population, they were performed at the same center and could introduce

selection bias given that other hospital populations were not included. Specific data points had to be extrapolated from the figures for POD 0 morphine requirements,¹¹ as well as certain VAS scores. Lack of homogeneity in outcomes measures and the nature of how the data were reported likely introduced bias into the meta-analysis, and meta-analysis was not possible for the visual analog scores. Strengths include high MINORS criteria for both included studies, rigorous approach to the search and data analysis using PRISMA guidelines, and in-depth consideration and calculation of the cost of regional anesthesia.

Conclusions

Regional anesthesia is an important modality of pain management in burn reconstruction. We have demonstrated superior pain control at the donor site, improved subjective experience at the first dressing change, and decreased narcotic consumption when regional blocks are employed. Regional anesthesia also is purported to improve early mobilization. Through literature review, it has been calculated that single-shot regional anesthesia is as effective as continuous regional anesthesia at half the cost. Pertinent future directions include impact analysis of regional anesthesia on hospital length of stay and cost of hospitalization.

Authors' Note

K.A.G., J.S., and A.R.K. all made substantial contribution to the concept and design, acquisition, analysis, and interpretation; drafted or revised the article for intellectual content; approved of this version; and take public responsibility for the content.

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