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Ultrasound-guided regional anesthesia for pediatric burn reconstructive surgery; a prospective study

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Abstract

Pediatric patients face multiple reconstructive surgeries to re-establish function and aesthetics post burn injury. Often, the site of the harvested graft for these reconstructions is reported to be the most painful part of the procedure and a common reason for deferring these reconstructive procedures.

This study in pediatric burn patients undergoing reconstructive procedures examined the analgesia response to local anesthetic infiltration versus either a single ultrasound guided regional nerve block of the lateral femoral cutaneous nerve, or a fascia-iliaca compartment block with catheter placement and continuous infusion.

Methods—19 patients were randomized to one of three groups (infiltration, single shot nerve block, or compartment block with catheter) and received intraoperative analgesia intervention. Post-operatively, visual analog scale pain scores were recorded –for pain at the donor site—every four hours while awake—for forty-eight hours.

Results—This non-parametric data was analyzed using a two way ANOVA, Friedman's test, and Kruskal-Walllis test, with significance determined at $p<0.05$. The analysis demonstrated that the patients in the regional anesthesia groups were significantly more comfortable over the 48 hour hospital course than the patients in the control group. The patients receiving a single shot block of the LFCN were more comfortable on post-operative day (POD) 0 while the catheter patients were more comfortable on POD 1 and POD 2. There was not a statistically significant difference in opioid requirements in any group.

Conclusions—Regional anesthetic block of the lateral femoral cutaneous nerve, with or without catheter placement, provides an improved postoperative experience for the pediatric patient undergoing reconstructive surgery with lateral/anterolateral skin graft versus local anesthesia

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infiltration of donor site. For optimal comfort throughout the postoperative period, an ultrasound guided block with continuous catheter may be beneficial.

Keywords

lateral femoral cutaneous nerve; split thickness skin graft; ultrasound guided regional anesthesia; pediatric burn management; postoperative analgesia

Introduction

Children that survive severe burns face many reconstructive procedures, spanning years to decades, in a quest to re-establish function and aesthetics [1]. These operations are varied but often involve the release of scarred tissue followed by harvesting and placement of a split-thickness skin graft. Almost always this split thickness donor site is the most painful aspect of the postoperative care. Because of this, a great deal of the burn literature deals with decreasing this postoperative pain, by better dressing management or by better pain management [2].

Children, and their parents, that elected to defer these reconstructive procedures, gave as the most common reason that the donor site pain was severe and pain control was inadequate. This was our impetus for the present study. The current standard of care for release and graft procedures is to harvest split-thickness donor tissue from a convenient and minimally aesthetically intrusive site; often the lateral thigh of the patient. The site is then, post-harvest, infiltrated with local anesthetic which supplies reasonable analgesia for the immediate postoperative period but usually does not last into postoperative day 1 or beyond. Local infiltration sometimes affords only partial analgesia due to volume and/or dose of local anesthesia restrictions in smaller patients.

Regional nerve blockade has been proposed for skin graft harvest [3-7] and may provide better and longer standing analgesia. We wanted to evaluate whether ultrasound guided regional anesthesia (USGRA) could improve the regional analgesia and thus the child's surgical experience. We designed a prospective randomized study evaluating donor site postoperative pain in 3 modes of analgesia: local infiltration, lateral-femoral cutaneous nerve block (LFCN), or fascia iliaca continuous infusion via an indwelling catheter.[6]

Methods

This study was approved by our institutional review boards, and informed consent was obtained from the parents of all subjects enrolled. The assent of each child was also obtained if the child was 7 years or older. The study was registered at the U.S. National Institutes of Health Clinical Trials Register (NCT01500655). Inclusion criteria of the subjects for study included the following: Pediatric burn patients undergoing reconstructive skin grafting, age >2 and ≤21, and lateral/anterior thigh donor site available. Exclusion criteria were: subject requiring narcotics pre-operatively, history of local anesthetic allergy, and subjects who were morbidly obese (BMI≥30) out of concern that USGRA would be too technically difficult.

Subjects were randomized to one of three groups: Group 1 (represents the current standard of care at our institution) received donor site infiltration with bupivacaine 0.25% with epinephrine 1:200,000; dose = 1 ml/kg (no maximum). Group 2 received a single injection of ropivacaine 0.2% (without epinephrine) around the lateral femoral cutaneous nerve via ultrasound guidance; dose = 20 ml or 1 ml/kg for children <20 kg. Group 3 received a fascia-Iliaca block under ultrasound guidance of ropivacaine 0.2%; dose = 20 ml or 1 ml/kg for children < 20 kg. A catheter was left in place in group 3 infusing ropivacaine 0.1% at 0.15 cc/kg/hr [19-20]. Randomization was via a random number generator with equal distribution to all three groups. However, if during the surgery a decision was made to harvest skin graft from areas other than the typical sensory distribution of the LFCN—and that patient had been designated group 2 (single shot LFCN block), then that subject would be re-randomized to either group 1 (local infiltration) or group 3 (fascia iliaca block/ catheter) as these techniques could cover anterior thigh innervation while LFCN block alone could not. The typical sensory distribution of the LFCN is described as the lateral aspect of the thigh from the inguinal ligament down to the knee so the surgical graft would only be taken from this area if an LFCN block was to be performed.

All blocks/catheter placements were performed at the end of the surgery, while the patient was still asleep. The anesthesiologist delivering the general anesthetic was not constrained in choice of technique nor whether or not narcotics were used intra-operatively. Similarly, airway management was determined by each anesthesiologist based on the patient's need for airway protection as well as the reconstructive surgery performed.

Data obtained for each study participant included age, gender, race, weight, size and location of graft, Visual Analog Scale (VAS), or Face, Legs, Activity, Cry, and Consolability Scale (FLACC) for children ≤6 years, every 4 hours while awake, narcotic requirements, and *when* narcotics first required. The VAS/FLACC questions were focused on *pain at the donor site*.

The blocking of the LFCN was performed using an ultrasound machine (GE Logiq, Milwaukee, WI) with a 12 mm linear probe. Our typical approach is to visualize the LFCN above the Sartorius muscle at the level of the femoral crease (personal communication Santhanam Suresh, MD) but many different approaches have been described. [3-8, 8-18]

All remained in-house patients for the duration of the study. This was not essential for the patients in the local infiltration or single injection groups, but occurred due to logistical issues that most of our patients are international, and return for dressing changes would have been very difficult.

Statistics

The analysis was conducted using the rank of data because of its non-parametric nature. Non-parametric two-way ANOVA was used to examine the relationship of pain score (comfort) with the treatment group and duration (Friedman's test). The association between comfort and treatment group was then assessed by non-parametric one-way ANOVA for each treatment day (Kruskal-Wallis test). Significance level was declared at $p<0.05$. The

treatment effect was then assessed each day, using non parametric one way ANOVA, the significance level was Bonferroni adjusted to $p<0.0125$.

Results

We enrolled 19 pediatric burn reconstructive patients who met the above inclusion criteria. All our subjects had a burn-contracture release procedure with split thickness skin graft harvested from the lateral, anterior-lateral, or anterior-lateral and medial thigh.

Data describing our study population, including age, weight, size of block, narcotics administered intra-op, postop, and treatment group, are summarized in Table 1.

The result from the two way ANOVA indicated a significant difference between the groups and on different days. These results are presented in Table 2. In the Post Anesthesia Care Unit (PACU) and Day 0, block treatment patients experienced better comfort than those of catheter; while catheter patients experienced better comfort on Day 1 and Day 2. Both block and catheter patients felt significantly more comfortable than the control group. The pain scores, means, standard deviations, and significance (P values based of Kruskal-Wallis tests) for all the treatment groups are listed for four time points in Table 2 (PACU, Postop Day 0 (once discharged from PACU to floor), Postop Day 1, and Postop Day 2).

Pain scores (VAS) in the immediate post-operative period PACU suggested a regional technique (single shot block and/or catheter) led to better comfort. However some of the patients (2/7) in the catheter group were quite uncomfortable in the immediate PACU time. This discomfort resolved with minimal analgesic prior to transfer to the floor but will be addressed in ‘discussion’ section.

The pain scores continued to be lower in the single-shot block and catheter groups during the rest of post-operative day 0.

On post-operative day 1, there began to be less difference between the control group and the single shot group, but the catheter group was still quite comfortable. The difference between control group and block group VAS scores was significant ($p<0.01$), but differences between the control versus catheter group and block versus catheter were highly significant with control versus catheter VAS scores ($p< 0.004$), and block versus catheter VAS scores ($p<0.005$).

By post-operative day 2—prior to stopping the catheter infusions, the group with the continuous infusion catheters were clearly the most comfortable with control versus catheter ($p<0.005$), and block versus catheter ($p<0.05$); the block versus control groups were not significantly different ($P<0.18$).

Narcotic use intraoperatively and in the post-operative period was measured. Table 1 shows this data. Although the data suggests narcotic use was less in the patients receiving regional anesthesia, this differences did not reach statistical significance. P values evaluating differences between all subject characteristics—including narcotic use—are presented at the bottom of Table 1.

Discussion

This study suggests that the pediatric burn patient may benefit from improved analgesia in the recovery period with a regional anesthetic block of the lateral femoral cutaneous nerve or a catheter in the fascia Iliaca compartment. This study was initially intended for thirty patients, but had to be halted, post an interim analysis which strongly favored the regional groups. The choice of 30 patients was based partially on convenience (i.e. how many pediatric reconstructive patients could we recruit) and on prior LFCN studies [9]. The pain scores were much lower in the regional nerve block groups than just local infiltration. Interestingly, at our institution, the pediatric in-patients interact together in a common play-room and would exchange information on this study. As this information became disseminated—and long before we halted the study—the patients would request the "catheter group" as this was perceived as the most comfortable way to have these procedures. In the catheter group, two patients arrived in the PACU having severe (9-10/10 pain) with one requiring 0.17 mg/kg of morphine and the other 0.05 mg/kg of morphine. Both patients were very comfortable for the remainder of the 48 hour study, with one requiring minimal analgesics (0.22 mg/kg morphine in total over three days) and the other no additional analgesics—and both stated they would want a catheter for their next reconstructive procedure. It may be that this is a result of slower onset of analgesia with a compartment block versus direct nerve block of the LFCN, or could be a function of anxiety of the subjects or pain at other sites from the procedures that the patients were incapable of differentiating from donor site pain immediately post anesthesia emergence.

This study does present several limitations. First, it is a small study of non-parametric data. Secondly, although requests were made to answer pain scores just regarding the donor site, this study was on pediatric patients who may have had difficulty differentiating pain at the grafted site versus at other surgical sites. Additionally, the patients had different reconstructive surgeries, and did receive supplemental opioid analgesics. All three groups received supplemental analgesics, in roughly similar amounts, and the differences were not statistically significant, but this may be another confounder. Because of the design of the study (large grafts that exceeded the distribution of the LFCN were randomized to control versus catheter) more surgeries with large donor site were in the control or catheter groups. As larger graft site may result in more pain, this is another potential confounder.

Pain at the donor sight has been addressed with local anesthesia and proven effective (multiple studies including (17)). It may be a continuous infusion makes the most sense for achieving the longest lasting analgesia as with our catheter group. Other investigators have also demonstrated this with Painbuster™ catheters placed in the subcutaneous space(18). The ultrasound guided blocks likely give more accuracy for the placement of the local anesthetic and could require less medication to achieve a greater area of pain control, but we are not aware of such a study having been performed. Clearly a long lasting, low dose, sensory block with minimal motor effects is optimal.

There were no adverse events performing these blocks, they were technically easy, were performed rapidly, and provided high patient and care-giver satisfaction.

Conclusion

Regional anesthetic block of the LFCN, with or without catheter placement, provides an improved postoperative experience for the pediatric patient undergoing reconstructive surgery with lateral/anterolateral skin graft. For optimal comfort throughout the postoperative period, an ultrasound guided block with continuous catheter catheter [19] may be beneficial.

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Table 1

Subject characteristics: Narcotics in equivalents of Morphine/kg

Treatment	Location	Wt (kg)	Age	Size of Graft (cm 2)	NarcoticsIntraop	Narcotics PACU	Narcotics POD 0	Narcotics POD 1	Narcotics POD 2
control	lat thigh	36	9	90	0.42	0.03	0.03	0.33	0.25
control	lat thigh	62	16	150	0.08	0.03	0.03	0.1	0
control	lat thigh	20	6	96	0.3	0.05	0.05	0	0
control	lat thigh	66	19	300	0.11	0	0.07	0.16	0.18
control	lat thigh	63	14	56	0.05	0	0.17	0.29	0.19
Mean		**49.40**	**12.80**	**138.40**	**0.19**	**0.02**	**0.07**	**0.18**	**0.12**
SD		**20.39**	**4.71**	**96.41**	**0.16**	**0.02**	**0.06**	**0.12**	**0.12**
block	lat thigh	55	17	175	0.13	0	0.04	0.25	0.13
block	lat thigh	57	15	60	0.3	0	0	0.05	0
block	lat thigh	70	10	50	0.14	0	0	0	0
block	lat thigh	44	11	60	0.13	0	0	0	0
block	lat thigh	34	10	84	0.26	0	0	0.07	0.03
block	lat thigh	30	9	48	0.13	0	0.06	0	0
block	lat thigh	32	8	60	0.28	0	0.09	0.09	0.35
Mean		**46.00**	**11.43**	**76.71**	**0.20**	**0.00**	**0.03**	**0.07**	**0.07**
SD		**15.15**	**3.31**	**44.89**	**0.08**	**0.00**	**0.04**	**0.09**	**0.13**
catheter	ant/lat thigh	60	18	90	0.24	0	0.02	0.25	0.12
catheter	lat thigh	44	9	60	0.07	0.00	0	0.06	0.06
catheter	ant/lat/med	48	16	300	0.16	0	0	0	0
catheter	ant/lat/med	60	17	150	0.42	0.17	0	0.11	0.11
catheter	lat thigh	54	16	45	0.13		0	0	0
catheter	lat thigh	60	18	150	0.33	0	0.02	0.05	0.05
catheter	ant thigh	37	7	96	0.32	0	0	0	0
Mean		**51.86**	**14.43**	**127.29**	**0.24**	**0.03**	**0.01**	**0.07**	**0.05**
SD		**9.14**	**4.50**	**86.15**	**0.13**	**0.07**	**0.01**	**0.09**	**0.05**
P-value		0.691	0.686	0.274	0.732	0.08	0.022	0.205	0.603

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Table 2

VAS/FLACC Pain Scores

	Control	Block	Catheter	P-value*
VAS PACU	9	0	0	
	5	0	0	
	3	0	0	
	5	0	0	
	5	0	10	
		0	9	
			0	
Mean	5.40	0.00	2.71	0.0103
SD	2.19	0.00	4.64	
VAS POD 0	4.5	0	2	
	2.2	0	0	
	3	0	0	
	2.7	1.4	0.3	
	5	1.5	2.7	
		0	0	
		0	0	
Mean	3.48	0.41	0.71	0.004
SD	1.21	0.71	1.14	
VAS POD 1	5.7	1.2	0	
	2.1	1.3	0.6	
	2.2	0.5	0	
	3	1.2	0.6	
	5.3	2.9	0	
		0.6	0	
		2	0.3	
Mean	3.66	1.39	0.21	0.0009
SD	1.72	0.83	0.29	
VAS POD 2	3.1	2.2	0	
	1.8	2.1	0.6	
	3.2	0	0	
	0.6	0	0	
		0	0	
		2	0	
			0	
Mean	2.18	1.05	0.09	0.0205
SD	1.23	1.15	0.23	

*This p-value tested the overall significance across intervention (control, block, catheter). Kruskal Wallis test was used.