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Comparison of Pain with Subcutaneous Lignocaine Infiltration based on Gate-control Hypothesis versus Conventional Bleb Formation before Passing Large-Bore Intravenous Cannula

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ABSTRACT

Objective: To measure the frequency of pain with two techniques of local infiltration, i.e. local infiltration by raising bleb with help of local anesthetic, and rubbing the site of infiltration of local anesthetic.
Study Design: Quasi-experimental study.
Place and Duration of Study: Anesthesia Department, Combined Military Hospital, Quetta Pakistan, from Mar to Aug 2023.
Methodology: A sample of 130 patients was divided into two equal groups: In Group-A, local anesthetic was infiltrated locally by raising a bleb and in Group-B, continuous rubbing was employed over infiltration site of local anesthetic. The frequency of pain was noted in both study group and Chi-square analysis was employed to compute statistical significance through *p*-value.
Results: The numerical rating score (NRS) was higher in Group-A patients as 52(80.0%) patients had NRS >4 while 13(20.0%) had NRS<4. In Group-B only 19(29.2%) patients had NRS >4 while 46(70.8%) patients had NRS<4. The difference was statistically significant (p<0.001).
Conclusion: We concluded that rubbing reduces pain scores during local infiltration into subcutaneous tissue utilizing gate-control hypothesis.

Keywords: Cannula, Gate-Control Hypothesis, Lidocaine, Local Anesthesia.

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INTRODUCTION

Pain is the foremost concern of an individual when surgery is advised. Although capability to feel pain is a part of protective physiological response as it alerts the individual of damaging stimuli reflex, it is characterized as a disease when it is recurrent and chronic.[1,2] Intravenous cannulation is a stepping stone in nearly every intervention. Though it is looked upon by health professionals as a very subtle and minute procedure but patients convey a lot of anxiety and dislike for it. It is associated with significant distress especially when it is secured after multiple attempts. Peripheral venous cannulation is considered a moderately painful procedure by 95% adults severely painful by 13%.[3] More than fifty percent of patients suffering from chronic disease experience a fear of needles, and 50% in chidlren.[4,5] This fear of pain during intravenous access results in failed phlebotomies in eighteen percent of the pediatric population.[6]

According to a meta-analysis that compared seventeen different methods of pain relief before intravenous cannulation, subcutaneous lignocaine (2%) was most reliable method of topical analgesia.[7]

One recently study has highlighted rubbing to prevent pain of propofol injection based on gate-control hypothesis. They established that rubbing along with lignocaine reduced pain scores by almost forty percent.[8] This gate-control mechanism serves as a crucial regulatory element, influencing the transmission and interpretation of pain signals before they reach the central nervous system, thereby shaping the overall pain experience.[9]

The rationale of our study was to utilize gate-control hypothesis to give local anesthetic before intravenous cannulation and compare it to a conventional technique of pain control.

METHODOLOGY

This Quasi-experimental study was carried out at Department of Anesthesia, Combined Military Hospital, Quetta Pakistan, from Mar to Aug 2023 after seeking approval from the Institutional Ethical Review Board (certificate number CMH QTA-IERB/12/2023).

Inclusion Criteria: Adult patients of either gender, with an age range of 18 to 60 years, who came to operation theater for different elective day care

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surgeries in whom intravenous cannula was passed in operation theatre were included.

Exclusion Criteria: Patients having neuro-psychiatric disorders, history of allergy to local anesthetics and patient already having a functional intravenous line in place were excluded.

The sample size was calculated by aid of WHO sample size calculator with anticipated percentage of patients to experience pain with rubbing (P1) to be 38% and the anticipated percentage of patients to experience pain without rubbing (P2) to be 80%.[10] The sample size came to 130 and we included 65 patients in each group. The groups were labeled as Group-A and Group-B after randomization by sealed envelope technique. In Group-A, local anesthetic was infiltrated locally by raising a bleb and in Group-B, continuous rubbing was employed over infiltration site of local anesthetic (Figure-1). We utilized non-probability consecutive sampling to collect the sample, after taking informed consent.

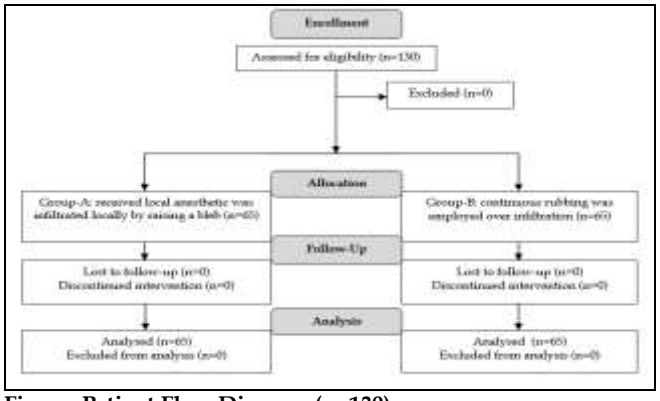

Figure: Patient Flow Diagram (n=130)

The patients who consented were booked electively through outpatient department of the hospital after thorough pre-anesthesia assessment in pre-anesthesia clinic. On the day of the surgery, they came to operation theatre without intravenous access. Group-B patients were laid supine on the operation theatre. The arm with largest and visible ante-cubital vein was identified by a preliminary inspection. The patient was asked to make a fist and abduct arm at 60 degree angle to the side of the body supported by an arm rest to prevent motion and achieve stabilization. Once suitable vein was identified skin was sterilized with help of spirit swab. One ml of lignocaine plain was filled in a 2-gauge insulin syringe with aseptic technique. Insulin syringe was introduced slowly into the subcutaneous tissue and vigorous rubbing was done immediately over the site of insertion of syringe into subcutaneous tissue. After this 1ml volume of lignocaine (2%) was injected slowly with continuous rubbing over it. The insulin syringe was slowly removed and gentle rubbing continued 10 seconds after that. The large bore intravenous cannula (20-gauge, 18-gauge, 16-gauge and 14-gauge) was inserted from same point from where the insulin syringe was introduced at angle of 30 degrees and advanced till the blood flashed in the Hub of cannula. If vein was not pierced at first attempt the cannula was re-directed in sub-cutaneous tissue to access the vein. Once the cannula was inside vein indicated by blood flashing in the hub of cannula, stylet was withdrawn and catheter was slowly advanced into the vein. The cannula was secured with transparent dressing. The intravenous fluid was attached to it and both forward and backward flow was checked to confirm its patency. The patient was asked to score their pain with help of numerical rating scale. We guided patient to point out the intensity of pain on the 11 point scale. The eleven points scale was used with zero representing absent pain and ten signifying the worst pain conceivable by the patient.[11] Similarly, Group-A patients were laid down on operation theatre table. The suitable vein was identified and arm abducted at 60 degree angle with respect to side of body. Once suitable vein was identified, skin was sterilized with the help of spirit swab. 1ml of lignocaine plain was filled in a 27 gauge insulin syringe with aseptic technique. Insulin syringe (27-gauge) was introduced slowly into the subcutaneous tissue and local anesthetic (1 ml of 2% lignocaine) was injected to raise a bleb. A large bore intravenous cannula (20-gauge, 18-gauge, 16-gauge and 14-gauge) was passed. The patient was asked to score their pain with help of Numerical Rating Scale (NRS). If cannula was not passed after three re-direction attempts or there was a double puncture indicated by swelling the needle was taken out and that cannulation attempt was excluded from the study. Following details were recorded regarding the patients: age, weight, Body Mass Index (BMI), gender, time taken for intravenous cannulation, NRS, Re-direction attempts and gauge of the cannula.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 23. Mean and standard deviation were computed for quantitative variables and frequency and percentages for qualitative variables. Chi square test (for qualitative variables), independent sample t-test (for quantitative data) were

applied and a p-value of <0.05 was considered significant.

RESULTS

The mean age of patients in Group-B was 42.95±8.68 years and in Group-A was 44.52±8.68 years. The mean weight in Group-B was 69.52±5.19 years versus 68.30±6.16 years in Group-A. There were 44(67.7%) males in Group-B and 21(32.3%) females in Group-A. In Group-B there were 35(53.8%) males and 30(46.2%) females. The time taken in both groups was also similar as there was no substantial difference, with it being 8.60±1.62 minutes in Group-B and 8.75±1.86 minutes in Group-A. Redirection attempts were similar in both groups. In 45(69.2%) Group-B patients, the cannula passed in first attempt, while this number was 56(86.2%) in Group-A. In 13(20.0%) Group-B and 7(10.8) Group-A patients, cannula was passed in second attempt. In 4(6.2%) Group-B patients and 7(10.8%) Group-A patients, there were 2 redirection attempts. Three redirection attempts were done in Group-B patients and while 3rd attempt was not done in any of Group-A patients (Table-I).

Table-I: Demographic Characteristics of the Study Groups (n=130)

		Group-A (n=65) Mean±SD	Group-B (n=65) Mean±SD	*p*-value
Age (years)		42.95±8.684	44.52±8.689	0.895
Weight (kg)		69.52±5.1965	68.308±6.1642	0.393
Time taken (minutes)		8.60±1.628	8.75±1.863	0.659
		n(%)	n(%)	
Gender	Male	44(67.7)	35(53.8)	0.075
	Female	21(32.3)	30(46.2)	
Redirection attempts	0	45(69.2)	56(86.2)	0.083
	1	13(20.0)	7(10.8)	
	2	4(6.2)	2(3.1)	
	3	3(4.6)	0(0)	

The numerical rating score (NRS) was higher in Group-A patients as 52(80.0%) patients has NRS >4 while 13(20.0%) had NRS<4. In Group-B only 19(29.2%) patients had NRS >4 while 46(70.8%) patients had NRS<4 in Group-B patients *p*-value <0.001 as shown in Table-II.

Table-II: Association of Numerical Rating Score (NRS) between both Study Groups (n=130)

Group	NRS<4 n(%)	NRS>4 n(%)	*p*-value
Group-B	46(70.8)	19(29.2)	<0.001
Group-A	13(20.0)	52(80.0)	

There were 14(21.5%) twenty-gauge cannula, 41(63.1%) eighteen-gauge cannula, 6(9.2%) sixteen-gauge cannulas and 4(6.2%) fourteen-gauge cannulas were used in Group-B patients while 12(18.5%) twenty-gauge cannula, 45(69.2%) eighteen-gauge cannula, 7(10.8%) sixteen-gauge cannulas and 1(1.5%) fourteen-gauge cannulas used in Group-A patients with *p*-value of 0.504 (Table-III).

Table-III: Different Cannula Gauges used in Study Groups (n=130)

Cannula Gauge	Group-B (n=65) n(%)	Group-A (n=65) n(%)	*p*-value
20-Gauge	14(21.5)	12(18.5)	0.504
18-Gauge	41(63.1)	45(69.2)	
16-Gauge	6(9.2)	7(10.8)	
14-Gauge	4(6.2)	1(1.5)	

DISCUSSION

Our study suggests that paying attention to a seemingly minor aspect can lead to significant relief in patients' suffering. It is common for a prefixed ideology to prevail, assuming that patients are mentally prepared for pain when they visit a hospital, resulting in intravenous cannulation being performed without local anesthesia. However, we emphasize the importance of making all possible efforts to ensure patients' comfort during medical procedures. The results of our study demonstrated that there was a remarkable decrease in pain score when local anesthesia was administered during intravenous cannulation. These findings underscore the significance of addressing patients' comfort needs and incorporating appropriate pain management strategies to enhance their overall healthcare experience.

Despite advances in various pain control techniques, local anesthetic administration continues to be the most effective and widely used method to mitigate pain during dental procedures.[11] They are using some devices based on gate-control hypothesis. Vibraject is one such device which utilizes a high-frequency vibration that is strong enough for the patient to perceive when it is applied to the injection needle. The concept behind its effectiveness is rooted in the gate-control theory, which proposes that interference stimulation, such as vibration, has the potential to reduce pain perception.[12] The effects of vibration on pain have been observed in both clinical and experimental contexts. According to the gate-control theory, vibration can act as interference stimulation and effectively alleviate pain. Vibrainject is an interesting application of vibration as a counter stimulation is when it is used in conjunction with an anesthetic injection. These sophisticated devices are not available in our operation theatre but there principle can be utilized to achieve the purpose.[13]

The use of distraction as a safe and cost-effective behavior management technique to mitigate pain and anxiety during anesthesia administration has been well-documented in literature.[14] Notably, employing cold and vibration as rapid-acting measures for distraction and pain relief has also been studied extensively. These methods have shown promising results in diverting patients' attention from painful stimuli, thus contributing to a more comfortable and less distressing experience during medical procedures.

Mancini *et al.,* provided compelling evidence supporting the existence of a spatial organization of touch-pain interactions within a singular dermatome. They highlighted that pain relief by touch was not merely due to distraction, in fact it indicated a general tendency of individuals to adjust pain levels downward, a phenomenon that we term "tactile analgesia." They provided evidence that tactile analgesia exhibits a distinct spatial gradient within the same dermatome. They also advised further investigation to better understand the underlying mechanisms involved in touch-pain modulation within a single dermatome.[15]

Busch *et al.,* found that reduction in pain and discomfort during lignocaine infiltration can be achieved through the application of the gate-control hypothesis. According to them, repetitive rapid pinching and shaking of the skin near the injection site stimulated low-threshold fibers through pressure and vibration. This activation leads to “gating” or diminishing of the pain stimulus, resulting in a decrease in the perception of pain. Hence, this technique has potential for effectively managing pain during medical procedures and may enhance patient comfort and overall satisfaction.[16]

Digital Rubbing Massage-Pain Relief is also based on the gate-control hypothesis. Digital Rubbing Massage-Pain Relief was used to comfort of breast cancer patients. The efficacy of DRM Pain Relief in positively impacting the comfort experienced by breast cancer patients and suggests its potential as a valuable intervention in this context.[17]

Nearly sixty years have passed since the inception of the gate-control theory, which initially introduced by Melzack and Wall, the primary therapeutic implication of which suggested that elevating A fiber input while reducing C fiber input could lead to analgesic effects. This concept significantly influenced the advancement of pain relief techniques such as neuromodulation through methods like transcutaneous nerve stimulation or spinal cord stimulation. These approaches have proven successful in numerous interventions designed to close the "gate" and have benefited thousands of patients seeking pain relief.[18]

Although gate-control hypothesis has been used by pain specialist in pain clinics and dentists, it is still not very popular among general anesthesiologists. Our study will highlight its routine use for intravenous cannulation and bring relief to patients.

LIMITATION OF STUDY

Our main limitation was a small sample size and single-centre approach, both of which limit our generalizability.

CONCLUSION

We concluded that rubbing reduces pain scores during local infiltration into subcutaneous tissue utilizing gate-control hypothesis.

Conflict of Interest: None.

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Authors’ Contribution

Following authors have made substantial contributions to the manuscript as under:

MR & KM: Data acquisition, data analysis, critical review, approval of the final version to be published.

CAA & AH: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SQ & KSA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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