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Assessing Preoperative Pain Sensitivity Predicts the Postoperative Analgesic Requirement and Recovery After Total Knee Arthroplasty. *A Prospective Study Of 178 Patients.*

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**Assessing Preoperative Pain Sensitivity Predicts the Postoperative Analgesic Requirement and Recovery After Total Knee Arthroplasty. A Prospective Study Of 178 Patients.**

**Abstract:**

**Background:**

To study the correlation between preoperative pain sensitivity and postoperative pain and analgesic requirements for patients undergoing primary total knee arthroplasty (TKA).

**Methods:**

Between December 2018 and April 2019, the pain sensitivity of 178 consecutive patients undergoing primary TKA was assessed preoperatively with a digital algometer. The patients reported the VAS (visual analog scale) score at three instances of needle prick (phlebotomy, glucometer blood sugar, intradermal antibiotic test dose), during the range of movements and completed the DASS (Depression, Anxiety, Stress Scale) score. Postoperative VAS score, analgesic requirement, and physiotherapy milestones were recorded in all of these patients on day 0 to day 4.

**Results:**

The average age of the patients was 64.13 years and 69.1% were females. Females had lower mean algometry values ( $56.12 \pm SD12.77$ ) compared to males ( $71.09 \pm SD18.78$ ) ( $p<0.001$ ). Higher DASS correlated with lower algometry values ( $p<0.001$ ). The postoperative VAS score was  $2.54 \pm 0.59$  on the day of surgery which increased to  $3.27 \pm 0.69$  on day 1 after mobilization ( $p<0.001$ ) and reduced to  $1.67 \pm 0.62$  on day 4. Low algometer score correlated with higher postoperative VAS score ( $p<0.05$ ), increased analgesic requirement, and opioid

utilization ( $p < 0.001$ ), delay in achieving an optimum range of movements ( $p < 0.001$ ) and independent ambulation ( $p < 0.001$ ).

### **Conclusion:**

Preoperative assessment of pain sensitivity predicts postoperative analgesic requirements and recovery. Patients with a lower pain threshold should be counseled preoperatively and also receive a better titration of analgesics perioperatively and prolonged physiotherapy.

### **Keywords:**

Pain sensitivity; VAS; Multimodal analgesia; Algometer; Total knee arthroplasty

**Type of study:** Prospective case series

**Conflict of interest:** Nil

### **Introduction:**

Despite the latest advances in total knee replacement surgery (TKA) involving newer designs in prosthesis and advanced surgical techniques, post-operative pain is a significant factor affecting patient satisfaction and overall outcome [1]. Earlier experience has been that nearly half of the patients undergoing TKA presented with extreme pain immediately after surgery [2–6]. Severe postoperative pain after TKA is not only an unpleasant experience to the patient but also negatively affects postoperative recovery [2,7,8]. Inadequately controlled peri-operative pain is a risk factor for early postoperative complications and also long-term pain [1,7,9–11]. Individuals with uncontrolled severe post-operative pain have higher chances of developing chronic knee pain post-TKA because of the sensitization of the nervous system

leading to long term dissatisfaction [9,10,12,13]. Unexplained pain after TKA without an identifiable problem is a major concern[5]. Pain is multi-factorial and managing postoperative pain is complex. Often there is an overdose of postoperative analgesics [7,13–15].

Studies have shown that substantial variability exists between individuals in basal pain sensitivity (BPS) and modulation, as assessed using quantitative sensory testing (QST) studied in both normal subjects and patients with chronic pain [16]. Algometry is a reliable objective assessment of BPS and has high Intra- and inter-observer reliability [17–19]. Further studies have shown that BPS and pain threshold (PT) is dependent on many demographic factors like the female gender [20,21], high anxiety levels [22], pre-existing pain, younger age, and opioid dependence [1,23]. We hypothesized that identifying patients who have a lower pain threshold and adjusting postoperative analgesic requirements accordingly would be one of the key factors for better pain relief after TKA and will also avoid the overdose of analgesics.

The techniques of postoperative pain control have improved and multimodal pain control, rapid recovery protocols, and out-patient arthroplasty have become very popular. In the USA in the second quarter of 2019, 36.4% of total knee arthroplasty was performed as an outpatient procedure according to the Medicare used national patient-level Medicare Fee-for-Service Part -A claims data. These rates varied widely across hospitals from 0% (10th and 25th percentiles) to 78% (90th percentile)[24]. In the systemic review on the safety of outpatient arthroplasty, the reviewers have concluded that the patients recruited for outpatient joint arthroplasty were younger, more active, and had suffered from fewer medical comorbidities than the more typical lower limb arthroplasty patient. Further research is also

needed to establish the optimal perioperative protocols [25]. Independent risk factors for developing a complication or requiring an inpatient stay after a TKA included general anesthesia, body mass index  $>35 \text{ kg/m}^2$ , diabetes, chronic obstructive pulmonary disease, congestive heart failure, hypertension, malnutrition, female gender, age  $>75$  years, minority ethnicity, and an American Society of Anesthesiologists score of 4 [26]. Knowing the pain sensitivity will always be an added value both for the patients undergoing surgery and the treating surgeon. This study aimed to measure the pre-operative pain threshold (PT) and correlate it with the postoperative analgesic requirement in patients undergoing TKA.

#### **Materials and Methods:**

After obtaining Institutional Review Board (IRB) approval, a prospective observational study was planned involving consecutive patients undergoing TKA between December 2018 and April 2019. 269 patients underwent primary TKA during this period. Patients undergoing revision TKA, bilateral single-stage total knee replacements, neuropathic joints, patients on cardiac pacemakers were excluded. All the patients rated the pain by VAS to the investigator during four instances pre-operatively namely:

1. Drawing blood from the cubital vein for blood sample collections.
2. Subcutaneous injection of a test dose of cefuroxime 0.5cc over the forearm.
3. Measuring the glucometer random blood sugar using pin-prick from the tip of right the index finger.
4. Pre-operative range of movement(ROM) of the operative knee.

All patients then underwent pain threshold (PT) measurement by using a digital algometer (Fig.1). This works on the principle of faradic electrical stimulation with two electrodes applied to the skin with constant pressure. PT was taken as the millivolts required to elicit a sensation of pain within 10 seconds of application. Measurements were started from 20 units

and gradually increased by 10 units and stopped when the patient felt a discernible sensation of pain. The mean of three values was considered as a final PT. Each patient underwent PT measurement on the (i) medial side of the operative knee, (ii) non-dominant hand over the first dorsal interosseous, and (iii) on the nape of the neck [16,17,19]. Algometer readings were recorded from the digital algometer. All readings were taken on the day before surgery by an arthroplasty fellow and these values were blinded from the observers who recorded the pre-operative and post-operative VAS.

The psychological analysis was done with Depression, Anxiety, and Stress Scale (DASS) self-reported scale [27–30]. The DASS is a set of three self-reported values designed to measure the emotional states of depression, anxiety, and stress. Each of the three DASS values comprises 14 items, adding up to a total of 42 items. It was administered just after PT recording. Simultaneously Knee society scoring (KSS) system was used.

#### **Analgesic protocol:**

All patients received oral paracetamol 1 gm, aceclofenac 100 mg, pregabalin 75 mg with methylcobalamin 1500 mg, and alprazolam 0.5 mg on the night before surgery, as pre-emptive analgesics [6,31,32]. All the patients were operated under combined epidural and spinal anesthesia with tourniquet inflated throughout the procedure until the setting of cement. Patients received peri-articular infiltration of 30 ml ropivacaine 0.5% with 15 ml of normal saline. Post-operatively patients were given an adductor canal block (20 ml 0.2% of ropivacaine + 10 ml of normal saline + 8 mg dexamethasone) to the operated side and buprenorphine 10mg/7 days skin patch. Intravenous paracetamol 1 gm was given 8<sup>th</sup> hourly, intravenous ketorolac 30 mg was given 12-hourly on the day of surgery (Day 0), followed by oral paracetamol 1 gm thrice daily, oral aceclofenac 100 mg 12-hourly, oral pregabalin 75 mg with methylcobalamin 1500 mg HS throughout the hospital stay. Intravenous tramadol 100

mg in 100 ml normal saline or intravenous fentanyl 40 mcg were used as rescue analgesics after recovery from spinal anesthesia. In patients with chronic kidney disease and acid peptic disease NSAIDs were replaced with intravenous tramadol 100 mg 12-hourly on the day of surgery and oral paracetamol 1 g TDS + oral tramadol 50 mg BD for 4 days. All patients received butorphanol 2mg on the night of surgery as a sedative. Oral alprazolam 0.5 mg given on the following nights for sedation. Any other opioid or other analgesics used or repeat nerve block or epidural top-up additional to this protocol were considered as additional analgesic requirements. Intermittent pneumatic compression device (IPCD) and aspirin were used for venous thromboembolism prophylaxis for all patients except for patients on clopidogrel, which was restarted after drain removal.

#### **Physiotherapy Protocol:**

Patients received CPM (continuous passive motion), static quadriceps strengthening exercise for the operated limb on the day of surgery under nerve block. Full weight-bearing of the operated limb commenced from day 1 postoperatively under the supervision of a physiotherapist. The range of movements was assessed preoperatively and postoperatively on days 1 - 4 postoperatively. CPM was increased daily to tolerable limit and the maximum range of movement achieved was documented. The need for physiotherapy assistance during ambulation and toileting was assessed on days 2 and 4 postoperatively. All patients achieved a minimum range of movement of 90° and were able to walk independently at the time of discharge.

#### **Postoperative assessment:**

The patient reported VAS at 2, 6, 12, and 24 hours postoperatively. From day 1 to 4 postoperatively VAS scores were recorded at rest, during CPM and full weight-bearing



walking. The mean of all three values was taken for comparison. The VAS score recordings were done by an independent observer (orthopedic postgraduate) before surgery and on days 1-4 postoperatively. On the day of surgery, the score was recorded by the nurses in the high dependency unit. All these observers and anesthetists were blinded for the algometer values. The total analgesic utilization was calculated from the case file and the physiotherapy assistance was assessed by knee ROM tolerated with CPM, walking distance, and need of assistance for toileting and mobilization distance on days 2 and 4. The analgesic requirement on the day of surgery and first-day post-surgery was decided by an anesthetic team in the high dependency unit and on subsequent days by the orthopedic team.

## STATISTICAL ANALYSIS

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean  $\pm$  SD and median. The normality of data was tested by the Kolmogorov-Smirnov test. If the normality was rejected then the nonparametric test was used.

Statistical tests were applied as follows-

1. Quantitative variables were compared using Mann-Whitney Test (MW)(as the data sets were not normally distributed) between the two groups and the Kruskal Wallis test (KW) between more than two groups.

2. Spearman's rank correlation coefficient was used to assess the correlation of VAS score at rest with at movement and preoperative VAS with postoperative VAS.

A p-value of  $<0.05$  was considered statistically significant.

The data were entered in Microsoft Excel and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

**Results:**

178 patients were included of which 123 patients (70%) were females. The average age was 64 years (58-70) and the majority (94%) of patients had osteoarthritis and the remaining had inflammatory arthritis. Valgus deformity was seen in 15 patients ranging from 5 to 20 degrees. The varus deformity ranged from 0-20 degrees. The associated co-morbidities included diabetes in 61, hypertension in 96, hypothyroidism in 20, heart-related ailments [ischaemic heart disease(IHD), atrial fibrillation(AF), rheumatic heart disease(RHD)] in 24, kidney-related illness (chronic kidney disease, elevated renal parameters) in 7 and others (cerebrovascular accident, bronchial asthma, a chronic obstructive pulmonary disorder(COPD), etc.) in 18 respectively. Established psychiatric illness was present in two patients (one with depression and the other with bipolar disorder) who were on treatment with antipsychotics for several years.

The average algometer value was  $60.74 \pm 16.37$  (range 26.66-120). For correlation of outcome to algometer values, the patients were divided into 4 groups. <40, 40-60, 60-80, >80. The distribution of patients in each group is 7%, 49%, 34%, and 10% respectively (Table 1). There was no correlation between age (p 0.4), preoperative diagnosis (p 0.14), fixed flexion deformity (p 0.5), or severity of deformity (p 0.74) with pain threshold. The correlation with other parameters and the analgesic requirement is as given below. One patient in <40 group, 3 patients each in the 40-60 group and 60-80 group had a deranged renal function in whom NSAIDs were avoided. None of the patients was opioid-dependent. All smokers ceased smoking at least 2 weeks before surgery.

**1. Sex, DASS & pain threshold:**

The average algometer value for females was  $56.12 \pm 12.77$  (range 26.66-90) and male  $71.09 \pm 18.78$  (range 30-120). A significant association was seen between gender and algometer

average and the algometer average in females was significantly lower than males ( $P < 0.0001$ ), Fig.2. 88% of females had an algometer value of fewer than 60 units ( $p < 0.0001$ ). A high algometry value of more than 80 units was seen in 27% of males compared to only 0.01% of females. These values have been shown in table 1.

A significant association was seen between depression, anxiety, and stress scale scores with the algometer values ( $p < 0.0001$ ). The mean value of depression, anxiety, and stress was significantly higher in patients with low average algometer value as compared to patients with high average algometer value. With the increase in algometer average from less than 40 units to more than 80 units, the mean value of depression, anxiety and stress decrease from  $5 \pm 2.35$  to  $0.65 \pm 1.06$ ,  $8.23 \pm 2.28$  to  $3.12 \pm 1.58$  and  $9.69 \pm 2.32$  to  $5.12 \pm 2.03$  respectively. This has been shown in table 1.

## **2. Preoperative VAS score, Knee Society and Function score & Algometric values:**

The preoperative visual analog score during blood sample collection, antibiotic test dose, glucometer random blood sugar (GRBS) and range of movements were  $2.48 \pm 0.85$ ,  $2.98 \pm 0.74$ ,  $1.21 \pm 0.89$  and  $7.25 \pm 0.91$  respectively. The maximum pain was felt during the preoperative range of movements (Table 2). Lower the algometry value higher was the preoperative VAS score (negative correlation,  $p$ -value  $< 0.0001$ ). A significant correlation was seen between algometer scores and knee society knee score and functional score ( $p < 0.001$ ). The mean value of functional and knee society score was significantly higher in patients with higher average algometer values (positive correlation).

## **3. Analgesic requirement & Postoperative VAS score**

Postoperatively, the average visual analog score within 24 hours (day 0) was  $2.58 \pm 0.59$ . On postoperative day 1, this increased to  $3.27 \pm 0.69$ , and then afterward a declining trend was

seen from  $3.27 \pm 0.69$  to  $1.18 \pm 0.58$  from days 1 to 4 postoperatively. The VAS scores of different algometer groups at different periods are given in Table 3 and Fig.3. A significant association was seen between the requirement of analgesics and total opioids utilized (Morphine mill-equivalence, MME) per day with the algometer scores ( $p < 0.0001$ ). The mean value of intravenous paracetamol, oral paracetamol, and total opioids utilized was significantly higher in patients with low average algometer value when compared to patients with high average algometer value. This has been described in Table 4. In the  $< 40$  group, 3 patients required repeat adductor canal block after 12 hrs and 2 patients required epidural top-up as rescue analgesics namely nerve blocks and opioids were inadequate.

#### **4. Postoperative ambulation & range of movements.**

The preoperative range of movements was comparable in all four algometry groups ( $p = 0.509$ ). The range of movement was  $90.87 \pm 12.53$  preoperatively. The VAS value increased on day 1 postoperatively after mobilization and CPM ( $p < 0.001$ ). On days 2 and 4 postoperatively, a significant association was seen between the range of movements and algometer scores ( $p < 0.0001$ ). Mean value of the range of movements postoperatively on day 2 and 4 were significantly lower in patients with low average algometer values as compared to patients with higher average algometer values ( $p < 0.0001$ ). This has been shown in table 5 and fig.4. The preoperative algometer score and VAS scores had a significant association with the postoperative requirement of assistance for ambulation and toileting. Patients with higher algometer average scores ( $> 80$ ) did not require any assistance for ambulation and toileting by day 4 postoperatively. This was in contrast to 76.4% of the patients with a low algometer score ( $< 40$ ) requiring assistance even on day 4 postoperatively ( $p < 0.0001$ ) (Fig.5). All the results are summarised in Fig.6.

**Discussion:**

This is a prospective study done to assess the basal pain sensitivity of patients undergoing knee arthroplasty objectively using a digital algometer. We have shown that the patients with low pain threshold (low algometer scores) have higher postoperative analgesic requirements, took longer to achieve optimum range of movements and independent ambulation . Hence, a proactive approach is necessary in providing better pain relief and a pleasant postoperative experience in such patients. This is the first instance where algometer readings were directly compared with postoperative pain and the analgesic requirement on the day of surgery and during the postoperative period. Therefore correlation to other studies in the literature is not possible. However, individual factors are compared from different studies.

Studies have aimed to determine the preoperative indicators of acute postoperative pain and outcome after a TKA[13,21,22]. Most of them have used subjective methods of assessing pain and other factors to determine pain and outcome. Very few studies have been done using combined objective and subjective factors to measure pain and outcome in orthopedic surgery. With algometer, one can objectively quantify the pain threshold of an individual in a reliable manner[16–19,33]. Quantitative sensory testing such as von Frey pain intensity and heat pain threshold has been shown to correlate to pre- and postoperative pain scores[23]. The visual analog scale score is a time-proven subjective means of quantifying the pain of a patient [33,34] and has been shown to correlate with algometer findings in earlier studies [34–36]. This prospective study has shown that by knowing the pain threshold of an individual preoperatively, we can titrate the analgesic requirement for the patient postoperatively to enhance pain relief.

**Female sex and pain threshold:**

Meghna Nandi et al. in her study on preoperative determinants of postoperative pain, female sex significantly correlated with heightened pre-surgical pain sensitivity and post-surgical pain intensity and correspondingly higher requirement of postoperative analgesics[20]. Linda S. Chesterton et al. in their study on healthy volunteers demonstrated that females exhibited significantly lower mean pressure pain threshold in the first dorsal interosseous muscle than males, which was maintained for fourteen repeated measures within 1 hour [36]. In our study we recorded similar results with females having significantly lower preoperative algometer scores compared to males and hence had higher postoperative VAS score and analgesic requirements postoperatively.

**DASS and pain threshold:**

Surgery can cause psychological stress and anxiety for patients. In the DASS assessment, many patients had higher preoperative scores for anxiety and stress and low scores for depression. The mean value was for depression 2.12 (normal, 0-9), anxiety 5.24 (normal, 0-7) and stress 6.98 (normal, 0-14) respectively. These scores were in the higher limits of normal, especially in patients with low algometric values with a mean of 5, 8.2, and 9.6 respectively. A significant correlation between preoperative DASS scores and preoperative pain sensitivity (algometry) ( $p < 0.0001$ ) was seen which indirectly means these patients had higher postoperative pain and analgesic requirement. This score represents the emotional status of the patients as it affects the pain perception processes. Studies by Patricia R. Pinto et al. [22] and Kornilov et al [21] on preoperative determinants of postoperative pain has shown that pre-surgical anxiety significantly correlated with heightened pre-surgical pain sensitivity and

acute postsurgical pain intensity and correspondingly higher requirement of postoperative analgesics. Patients with major depressive disorder experience increased perception of pain and higher opioid consumption following total joint arthroplasty [9,10,37–39].

#### **VAS score and pain threshold:**

Patients with higher preoperative VAS scores had higher acute postoperative pain, requiring a higher dosage of analgesics in the immediate postoperative period. In the study comparing the preoperative VAS score with postoperative functional outcome by Victoria et al. they found that, despite there being no significant difference in the preoperative knee society function score between patients with a preoperative VAS score  $< 40$  and  $> 40$ , there was a significant difference in the knee society function score at 6 months and 1 year. A greater preoperative pain predicted worse function as indicated by the knee society function scores at 1 year after surgery. Greater preoperative pain also predicted the use of more home physical therapy visits and longer inpatient rehabilitation stays. Patients with greater preoperative pain had more postoperative manipulations than patients with less preoperative pain [10]. In our study there is a strong correlation between preoperative VAS scores with algometer values and hence it can predict delayed recovery postoperatively.

Christopher et al. in their study assessing postoperative pain and opioid utilization found that the mean and standard deviation of the “The NRS” (Numerical Rating Scale) was  $2.08 \pm 2.84$  in the postoperative care unit (PACU),  $3.43 \pm 2.67$  on the day of surgery post-PACU,  $3.78 \pm 2.47$  on postoperative day 1,  $3.9 \pm 12.6$  on postoperative day 2,  $2.96 \pm 2.5$  on postoperative day 3. The opioid utilization ranged from 3.8 to 244.1mg/d, with a mean of 81.6mg/d and an SD of 45.1mg/d. The average pain NRS scores and MME (Morphine mill- equivalence) per day significantly correlated, with those reporting higher pain scores also requiring higher total daily opioids[39]. In our study, the postoperative VAS score was  $2.54 \pm 0.59$  on the day

of surgery which increased to  $3.27 \pm 0.69$  on day one and reduced to  $1.67 \pm 0.62$  on day 3. The mean opioid utilization was  $84.27 \pm 137.62$  (Morphine milligram equivalence, MME) which is comparable.

The pain management protocol we have used is in line with the standard recommendations[41] and now the adductor canal block with peri-articular infiltration is a standard practice[42]. In a study by Qiuru Wang et al comparing adductor canal block with posterior capsular infiltration with adductor block alone, the VAS values at 24 hours and 48 hours during rest were  $3.51 \pm 1.04$  and  $2.62 \pm 0.81$  respectively and  $4.93 \pm 1.03$  and  $4.71 \pm 1.22$  after movements[42]. This variation with rest and movement has been documented in our study with mean VAS score being  $2.58 \pm 0.59$  within 24 hours (Day 0) and increasing to  $3.27 \pm 0.69$  on day 1 following mobilization in the low algometer group ( $<40$ ). There is also the wearing off of the effect of the adductor canal block and the intra-articular infiltration after 24 hours. Patients with very poor pain tolerance i.e algometer scores  $< 40$  will benefit from repeat adductor canal block on day 1 postoperatively. However, in our study, only 3 patients received repeat adductor canal block and no significant correlation could be drawn. For patients with high pain sensitivity, having high pain scores (VAS  $> 6$ ) in the immediate postoperative period epidural top-up analgesia is another option. In our study, only 2 patients received epidural top-up and no significant correlation could be drawn. Epidural top-up or a continuous infusion comes with the drawback of delayed rehabilitation due to weakness of the lower limb musculature but avoids over-dependence on opioids. Though these blocks and epidural analgesics have shown to reduce opioid consumption[7,14,15] patients with lower algometer scores required analgesics and opioids at a higher dosage and for a longer duration.



**VAS and postoperative mobilization:**

Maximum pain is experienced on the first postoperative day after mobilization. This has been reported by Gerbershagen HJ et al. [43] and this has been the case in our study. The mean VAS in the < 40 algometer group was  $4.36 \pm 0.52$  on the first postoperative day compared to  $4.15 \pm 0.8$  on the day of surgery. This is true for all the other groups as well. Rackel BA et al reported that patients with severe movement pain preoperatively were 20 times more likely to have severe movement pain postoperatively. Quantitative sensory tests performed preoperatively on 215 participants scheduled for a unilateral TKR measured before surgery and on postoperative day 2, showed that predictors of moderate or severe movement pain were higher preoperative movement pain, von Frey pain intensity, and heat pain threshold. Significant predictors of moderate to severe resting pain were higher preoperative resting pain, depression, and younger age. These results suggest that patients with higher preoperative movement pain and depression are more likely to have higher pain following TKR, and younger patients may have higher resting pain. Cutaneous pain sensitivity predicted movement pain but not resting pain, suggesting that mechanisms underlying movement pain is different from resting pain [23]. Our study shows that both resting pain and movement pain were higher in patients with lower algometry values as resting pain was assessed on the day of surgery itself. The postoperative pain corresponds to higher movement pain, which again is significantly correlated to low algometry values. Hence our TENS type of algometry is useful for both types of pain.

Further significant association ( $p < 0.0001$ ) was found between preoperative algometer score, VAS score, and postoperative requirement of assistance for mobilization and assistance for toileting. Patients with higher algometer average scores ( $>80$ ) did not require any assistance

for mobilization and toileting by day 4 postoperatively. This is in contrast to 76.4 % of the patients with a low algometer score (<40) requiring assistance even by 4th postoperative day. To conclude preoperative pain threshold measurement and preoperative VAS as a measure of pain sensitivity is a reliable method of evaluation. The pain sensitivity was significantly higher in the female sex. In patients undergoing total knee replacements, those patients with high pain sensitivity have more postoperative pain, require more analgesics, and have prolonged post-operative rehabilitation. In contrast, patients with high algometric values may be considered for fast track protocol. The digital algometry is a non-invasive objective testing of pain sensitivity and can be easily administered. This could be added as a part of routine pre-operative assessment so that we can optimize the postoperative for these pain-sensitive patients.

#### ***Limitations of our Study:***

Our study is not without limitations. Only one modality of measuring pain was used (electrical stimulation vs pressure pain threshold, hot-cold pain, etc.). The readings of an algometer are variable from patient-to-patient and time-to-time. We tried to overcome this limitation by repeating three different readings for each patient and calculating the mean. This is a short-term study, and these patients need to be followed up for the long term to see the effects of acute pain on chronic pain and this correlation to algometry. Thirdly is the question of the relevance of this study in the era of fast track protocol and day-care arthroplasty. The average stay in the hospital for our patients was 4 days. The hospital stay is inexpensive and it's covered by the insurance. 69% were females and the average age of our patients was 64.13 years. 25% of our patients had major comorbid factors including renal failure, heart disease(IHD, AF, RHD), previous stroke, bronchial asthma, and COPD. But the article deals with the evaluation of the perception of the pain of the patient and if it can be

assessed reliably by a preoperative algometer study. So it will have relevance even to the group of patients who are now undergoing day-care arthroplasty because these patients do feel the pain in the first few postoperative days after total knee replacement. Despite these limitations, our study is unique and there are very few studies that analyze the effects of pre-operative pain sensitivity with analgesic requirement and postoperative outcomes.

#### **Conclusion:**

Preoperative assessment of pain sensitivity predicts postoperative analgesic requirements and recovery. Patients with lower pain threshold should be counseled pre-operatively and also receive a better titration of analgesics perioperatively and prolonged physiotherapy.

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## Tables

**Table 1: Association of gender, depression, anxiety, and stress with algometer.**

Scores		Algometer average (units)				P value
		<40 (n=13)	40-60 (n=88)	61-80 (n=60)	>80 (n=17)	
Female	123	11 (8%)	73 (71%)	37(0.3%)	2 (0.01)	<0.0001
Male	55	2 (3%)	15 (27%)	23 (41%)	15 (27%)	
Total	178	13 (7%)	88 (49%)	60 (34%)	17 (10%)	
Depression	Mean $\pm$ SD	5 $\pm$ 2.35	2.59 $\pm$ 1.74	1.23 $\pm$ 1.03	0.65 $\pm$ 1.06	<0.0001
Anxiety	Mean $\pm$ SD	8.23 $\pm$ 2.28	5.82 $\pm$ 1.96	4.35 $\pm$ 1.45	3.12 $\pm$ 1.58	<0.0001
Stress	Mean $\pm$ SD	9.69 $\pm$ 2.32	7.74 $\pm$ 1.98	5.82 $\pm$ 1.38	5.12 $\pm$ 2.03	<0.0001

**Table 2: Preoperative visual analogue score**

(Mean $\pm$ SD)	Algometer average (units)				P value
	<40 (n=13)	40-60 (n=88)	61-80 (n=60)	>80 (n=17)	
VAS score- Intravenous blood sample collection	3.85 $\pm$ 0.38	2.85 $\pm$ 0.52	1.98 $\pm$ 0.5	1.24 $\pm$ 0.75	<0.0001
VAS score - Intradermal antibiotic test dose	4.15 $\pm$ 0.38	3.32 $\pm$ 0.47	2.5 $\pm$ 0.54	2.06 $\pm$ 0.43	<0.0001
VAS score - Glucometer RBS estimation	2.77 $\pm$ 0.44	1.59 $\pm$ 0.58	0.65 $\pm$ 0.61	0 $\pm$ 0	<0.0001
VAS score - During range of motion	8.77 $\pm$ 0.44	7.6 $\pm$ 0.54	6.72 $\pm$ 0.61	6.18 $\pm$ 1.13	<0.0001
Knee society score	32.54 $\pm$ 6.84	36.51 $\pm$ 7.62	42.23 $\pm$ 7.35	39.88 $\pm$ 9.1	<0.0001
Functional score	18.46 $\pm$ 4.74	31.1 $\pm$ 9.84	42.92 $\pm$ 8.6	43.94 $\pm$ 12.93	<0.0001



**Table 3: Postoperative visual analogue score**

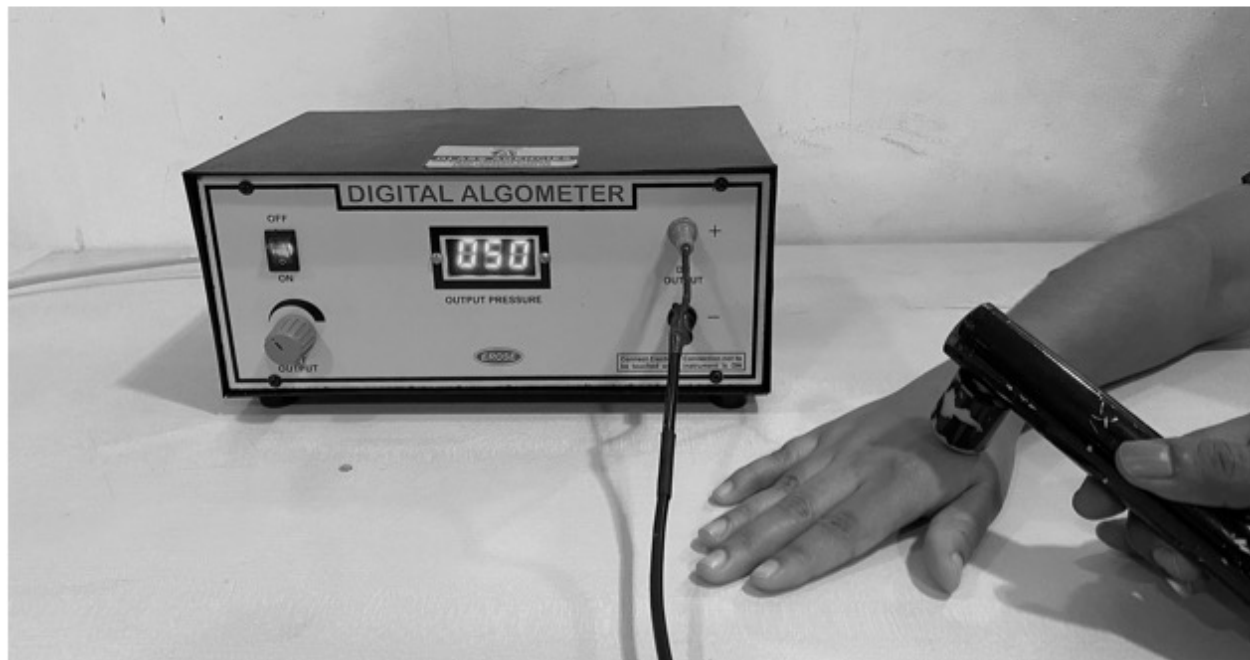
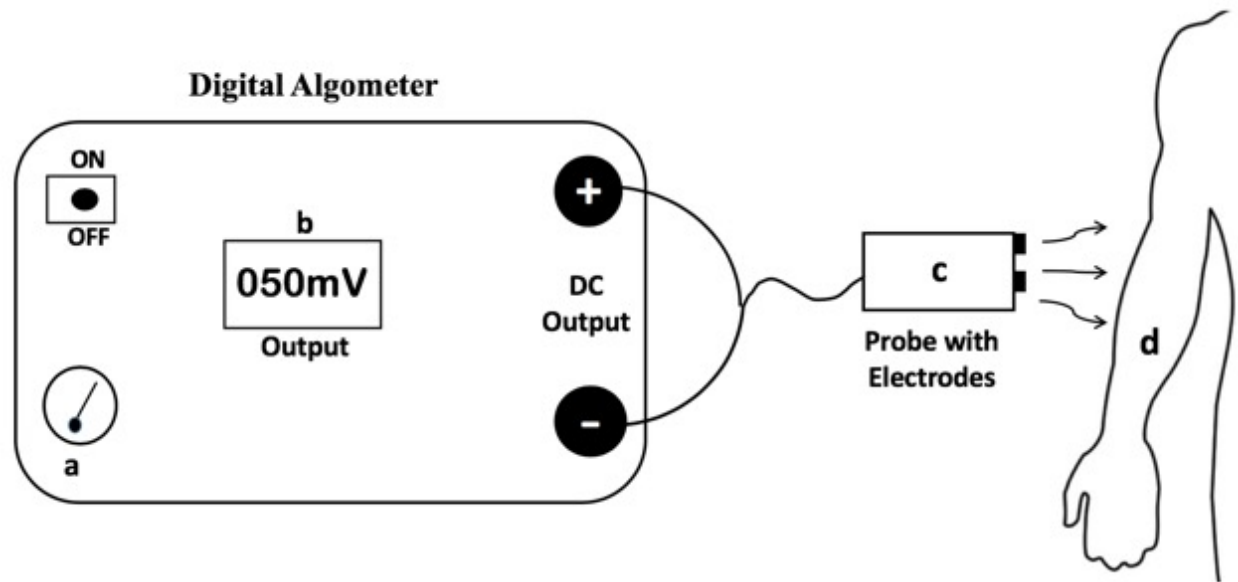
<b>Visual analogue score at different time periods (Mean <math>\pm</math> SD)</b>	<b>Algometer average (Newton)</b>				<b>P value</b>
	<b>&lt;40 (n=13)</b>	<b>40-60 (n=88)</b>	<b>61-80 (n=60)</b>	<b>&gt;80 (n=17)</b>	
<b>At 2 hours</b>	4.23 $\pm$ 1.01	2.9 $\pm$ 0.77	2.17 $\pm$ 0.67	1.24 $\pm$ 0.75	<0.0001
<b>At 4 hours</b>	3.54 $\pm$ 1.05	3.14 $\pm$ 0.86	2.23 $\pm$ 0.72	1.59 $\pm$ 0.94	<0.0001
<b>At 6 hours</b>	3.15 $\pm$ 0.99	2.58 $\pm$ 0.72	1.9 $\pm$ 0.73	1.18 $\pm$ 0.95	<0.0001
<b>At 8 hours</b>	2.62 $\pm$ 0.77	2.43 $\pm$ 0.74	1.85 $\pm$ 0.84	1.41 $\pm$ 0.94	<0.0001
<b>At 12 hours</b>	3.15 $\pm$ 0.69	2.38 $\pm$ 0.68	2.18 $\pm$ 0.72	1.82 $\pm$ 0.88	<0.0001
<b>At 24 hours</b>	4.15 $\pm$ 0.8	3.49 $\pm$ 0.61	2.83 $\pm$ 0.59	2.06 $\pm$ 0.56	<0.0001
<b>Average VAS Day 0</b>	3.47 $\pm$ 0.34	2.82 $\pm$ 0.32	2.19 $\pm$ 0.34	1.55 $\pm$ 0.43	<0.0001
<b>Post-operative day 1</b>	4.36 $\pm$ 0.52	3.61 $\pm$ 0.39	2.79 $\pm$ 0.4	2.35 $\pm$ 0.51	<0.0001
<b>Post-operative day 2</b>	3.31 $\pm$ 0.32	2.72 $\pm$ 0.32	2.08 $\pm$ 0.42	1.35 $\pm$ 0.55	<0.0001
<b>Post-operative day 3</b>	2.49 $\pm$ 0.32	1.99 $\pm$ 0.36	1.28 $\pm$ 0.49	0.76 $\pm$ 0.39	<0.0001
<b>Post-operative day 4</b>	1.95 $\pm$ 0.27	1.48 $\pm$ 0.4	0.79 $\pm$ 0.38	0.41 $\pm$ 0.28	<0.0001

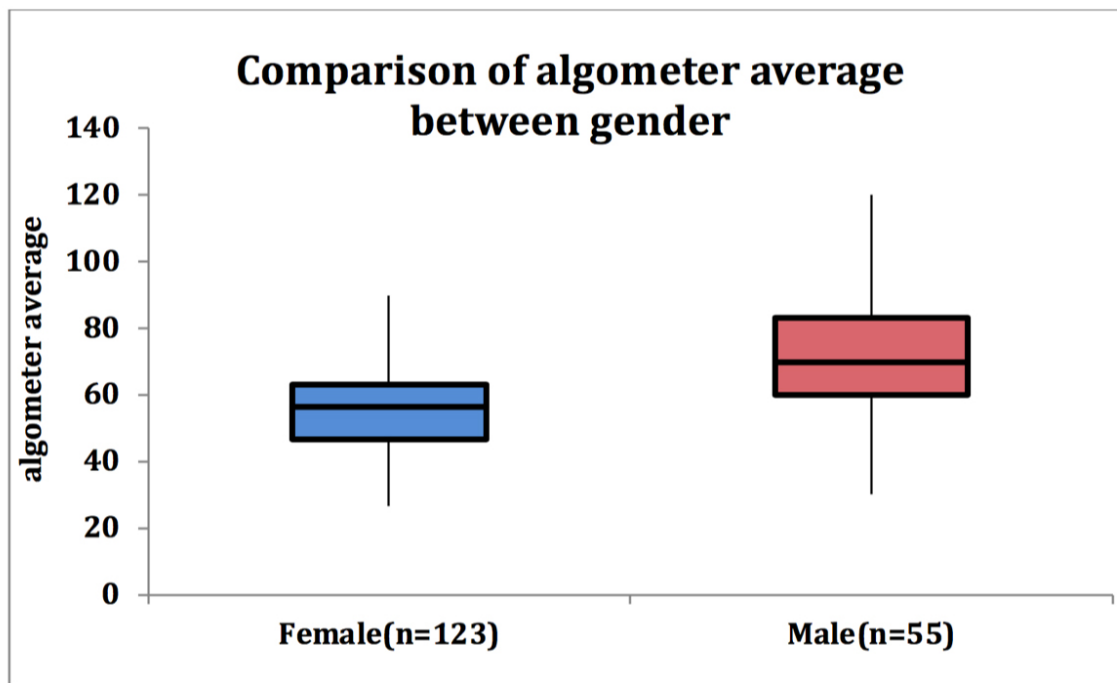
**Table 4: Descriptive statistics of amount of analgesics given over 5 days.**

<b>Dose of analgesic used Mean <math>\pm</math> SD</b>	<b>Algometer average (Newton)</b>				<b>P value</b>
	<b>&lt;40(n=13)</b>	<b>40-60(n=88)</b>	<b>61-80(n=60)</b>	<b>&gt;80(n=17)</b>	
Intravenous Paracetamol(g)	4.31 $\pm$ 1.11	3.51 $\pm$ 0.74	3.03 $\pm$ 0.18	3 $\pm$ 0	<0.0001
Intravenous Ketorolac (mg)	64.61 $\pm$ 16.64	60.68 $\pm$ 11.12	58 $\pm$ 10.86	60 $\pm$ 0	0.206
Oral Paracetamol (g)	15.69 $\pm$ 1.11	13.14 $\pm$ 1.81	12.13 $\pm$ 0.72	12 $\pm$ 0	<0.0001
Aceclofenac (mg)	784.62 $\pm$ 55.47	781.82 $\pm$ 98.9	773.33 $\pm$ 144.82	800 $\pm$ 0	0.74
Opioids (mg)	35.19 $\pm$ 15.09	11.28 $\pm$ 13.23	0.67 $\pm$ 3.62	0.59 $\pm$ 2.42	<0.0001

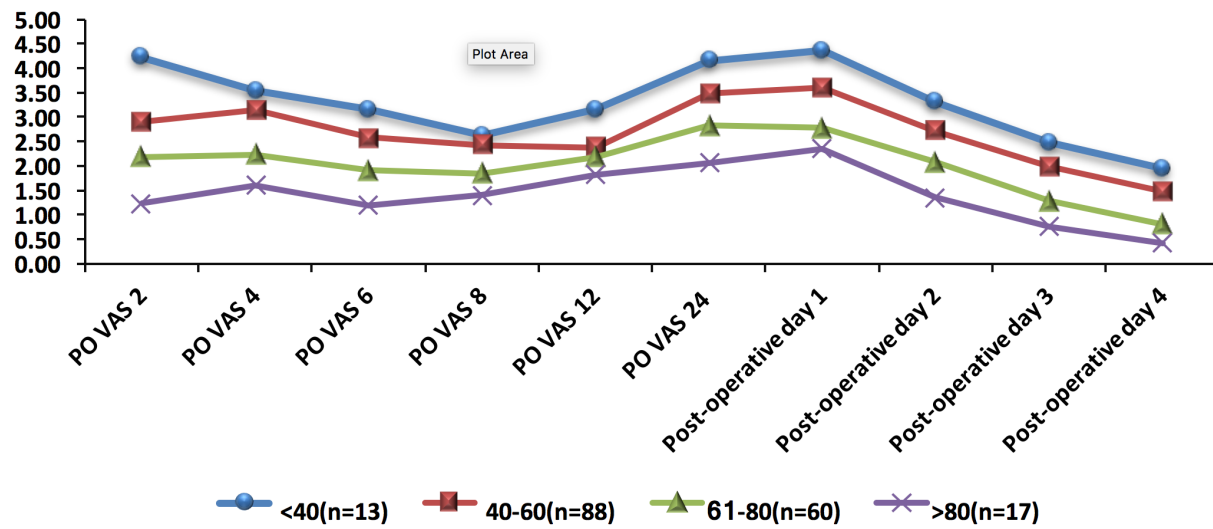
**Table 5: Association of range of motion with CPM at different time periods with algometer.**

<b>Range of motion Mean <math>\pm</math> SD</b>	<b>Algometer average (Newton)</b>				<b>P value</b>
	<b>&lt;40(n=13)</b>	<b>40-60 (n=88)</b>	<b>61-80 (n=60)</b>	<b>&gt;80(n=17)</b>	
Preoperative	92.69 $\pm$ 12.01	89.6 $\pm$ 13.07	92.5 $\pm$ 11.1	90.29 $\pm$ 14.9	0.509
Postoperative day 2	34.62 $\pm$ 10.7	49.15 $\pm$ 9.74	63.83 $\pm$ 8.6	73.53 $\pm$ 7.45	<.0001
Postoperative day 4	64.23 $\pm$ 9.97	74.83 $\pm$ 7.93	87.92 $\pm$ 6.2	98.53 $\pm$ 5.23	<.0001

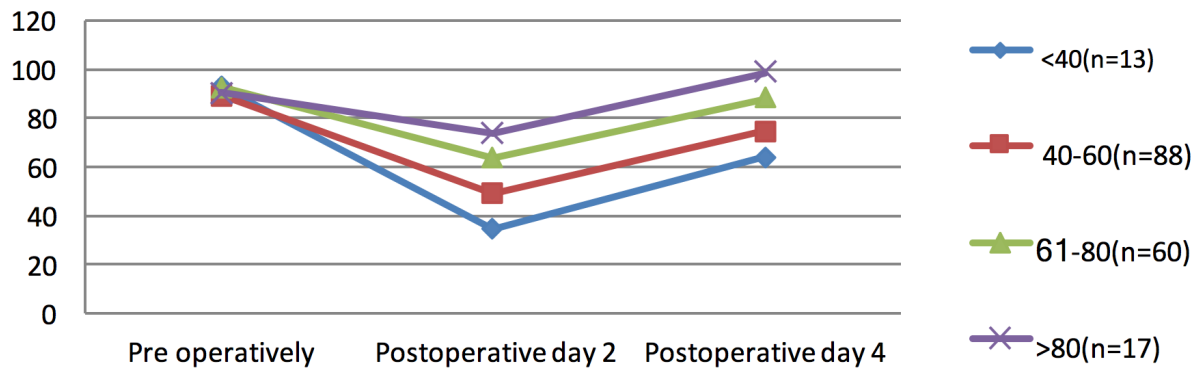


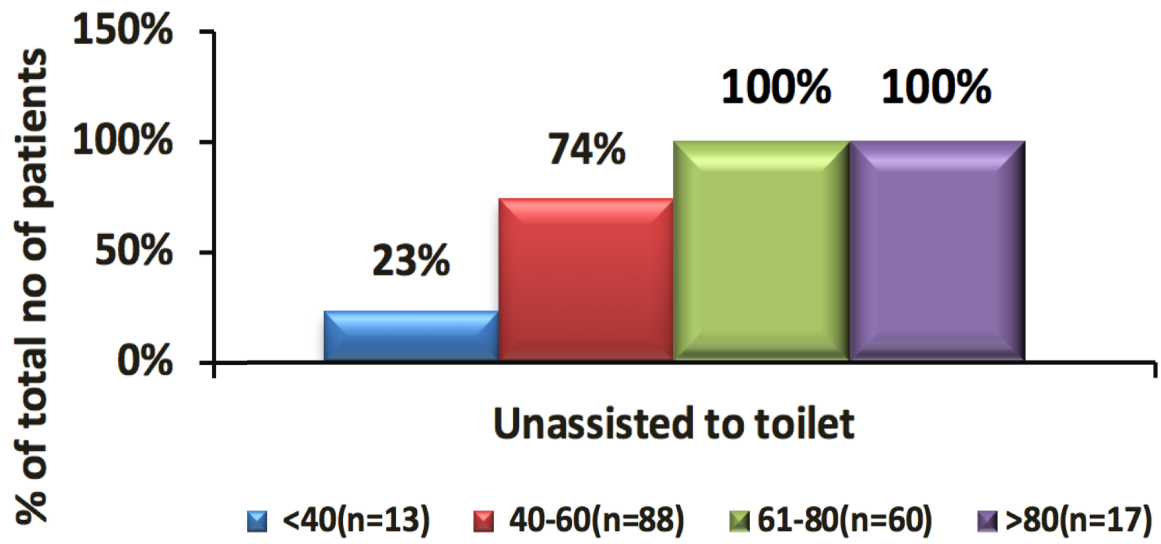


### Association of postoperative visual analogue score at different time periods with algometer



## Association of range of motion at different time periods with algometer





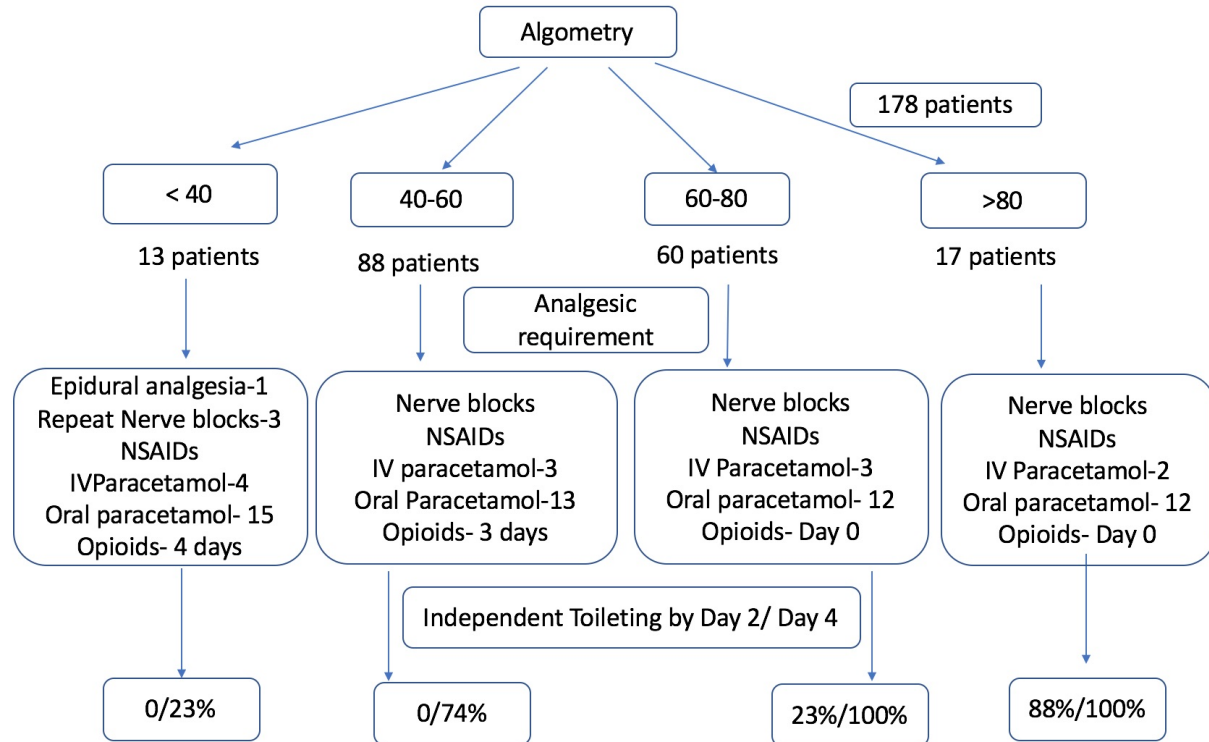




Figure Legend:

**Fig.1: Digital Algometer.** The alternate current is converted to direct current. The intensity of the direct current can be controlled by a voltage controller(a) which can be read off a LED display(b). This current can be applied through a probe(c) to the test subject(d) .

**Fig.2: Association between gender and algometer values.** Females have lower algometric values.

**Fig.3: Association of postoperative visual analogue score at different time periods with algometer.** PO VAS 2 -24 indicates VAS recorded on the day of surgery in the HDU from 2 hours to 24 hrs postoperatively. Higher VAS scores were recorded in the < 40 and 40-60 algometer groups. VAS score also increased on postoperative day 1 after mobilisation.

**Fig.4: Association of range of motion during CPM at different time periods with algometer.** The low algometer groups had lower tolerance to CPM and range of movements achieved was less even on the fourth postoperative day.

**Fig.5: Correlation between algometer values and independent toileting on postoperative day 4.** Even on day 4 patients with low algometric values have difficulty in walking to the rest room and using the western commode.

**Fig.6: Flow chart showing the algometry groups & outcome measured.** Patients with the least scores(<40) required more medications and their recovery was delayed.