Continuous paravertebral block by intraoperative direct access versus systemic analgesia for postthoracotomy pain relief

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Abstract

Background: Systemic analgesia with paracetamol and nonsteroidal anti-inflammatory drugs plus opioids as a rescue medication had reported to be better than that depend mainly on opioids for postoperative pain relief. Thoracic paravertebral block reported to provide a comparable postthoracotomy pain relief to epidural analgesia, with fewer side effects due to its unilateral effect. Thoracic paravertebral catheter can be inserted intraoperatively under direct vision during thoracic surgery (Sabanathan's technique). This prospective randomized study was designed to evaluate the safety and efficacy of this technique with continuous infusion of lidocaine compared to systemic analgesia for postthoracotomy pain relief.

Results: Sixty-three patients were randomized to receive a continuous infusion of lidocaine in the paravertebral catheter for 3 postoperative days (thoracic paravertebral group, $n = 32$) or systemic analgesia (systemic analgesia group, $n = 31$). All patients underwent standard posterolateral thoracotomy. There were no significant differences between both groups in age, sex, side, type, and duration of operation. Pain scores measured on visual analogue scale and morphine consumption were significantly lower in thoracic paravertebral group in all postoperative days. Spirometric pulmonary functions were not reaching the preoperative values in the third postoperative day in both groups, but restorations of pulmonary functions were superior in paravertebral group. No complications could be attributed to the paravertebral catheter. Side effects, mainly nausea and vomiting followed by urinary retention, were significantly more in systemic analgesia group ($P = 0.03$). Also, pulmonary complications were more in systemic analgesia group but not reaching statistical significance ($P = 0.14$).

Conclusion: Continuous paravertebral block by direct access to the paravertebral space using a catheter inserted by the surgeon is a simple technique, with low risk of complications, provides effective pain relief with fewer side effects, and reduces the early loss of postoperative pulmonary functions when compared to systemic analgesia.

Keywords: Paravertebral block, Postthoracotomy analgesia, Systemic analgesia, Sabanathan's technique, Lidocaine infusion

Background

Postthoracotomy pain is responsible for ineffective ventilation with inability to breathe deeply and mucous plugging leading to atelectasis, hypoxia, and ventilation perfusion mismatch predisposing to pulmonary infection and pulmonary complications [1, 2]. Multiple modalities were used to provide sufficient pain control with varying success: thoracic epidural, thoracic paravertebral, intrathecal, intercostal, interpleural analgesic techniques, and systemic analgesia [2–5]. Thoracic paravertebral block provides a comparable pain relief to epidural analgesia, with less side effects due to its unilateral effect [2, 6–9]. Recently, the group of procedure specific postoperative pain management (PROSPECT) of the European society

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Deebis *et al. The Cardiothoracic Surgeon*   (2020) 28:17

Page 2 of 7

of regional anesthesia and pain therapy recommends thoracic paravertebral block (TPVB) with local anesthetics as a bolus preoperatively or at the end of the operation followed by continuous infusion as the first choice compared to thoracic epidural analgesia (TEA) as TPVB has a lower rate of complications [10]. The main disadvantage of TPVB technique is the lack of familiarity [11]. The conventional and the most commonly used technique for paravertebral block depends on loss of resistance to air technique for percutaneous insertion of the catheter that can be aided with ultrasound guidance or nerve stimulation, and this is usually done by the anesthetist [12, 13]. Thoracic paravertebral catheters can also be safely inserted with ease under direct vision during thoracic surgery by the surgeon (Sabanathan's technique) [14–16].

This study was designed to evaluate the safety and efficacy of TPVB by intraoperative insertion of the catheter directly into the paravertebral space with postoperative continuous infusion of lidocaine on postthoracotomy pain as compared to systemic analgesia.

Methods

This prospective study was conducted in our center after approval from our University Institutional Research Board (IRB) and written informed consent from all patients, in the period from June 2015 to January 2020. The study was registered in ClinicalTrials.gov (ID: NCT04482192).

Inclusion criteria were the adult patients scheduled to undergo elective posterolateral thoracotomy for pulmonary procedures with American Society of Anesthesiologists (ASA) physical status of II and III and body mass index (BMI) between 25 and 35 kg/m^2.

Exclusion criteria were patients younger than 18 years, emergency surgery, previous thoracotomy, drug addiction, allergy to paracetamol (acetaminophen) or ketorolac, allergy to local anesthetics used, coagulopathy, hepatic dysfunction, chronic renal failure, history of gastric ulcer or bronchial asthma, or lack of patient consent.

Randomization into two groups, thoracic paravertebral block (TPVB) group and systemic analgesia (SA) with 1:1 allocation, was done by sealed envelopes that were prepared with a computer-generated randomization.

Patient's sample

Based on a pilot study of 20 patients, 10 in each group, the mean visual analogue scores of pain at rest (VAS) ± SD at 6 h postoperatively for TPVB patients were 3.0 ± 1.4 and that for SA patients were 4.2 ± 1.6. The calculated significant sample size with a power of 0.85 and alpha error of 0.05 was 60 patients, with 1:1 allocation in each group.

Eighty-two patients were assessed for eligibility criteria to be included in the study, 18 patients were excluded pre-randomization, and one patient was excluded post-randomization due to re-exploration for bleeding. Sixty-three patients were analyzed in the study. Thoracic paravertebral block group (TPVB group) included 32 patients, and systemic analgesia group (SA group) included 31 patients (Fig. 1).

On the day before operation, patients were trained for the use of the paper-based visual analogue scale (VAS) for pain assessment. The VAS consists of a horizontal line of 10 cm long orientated from the right (0 = no pain) to the left (10 = worst pain imaginable). The patient places a mark on the line corresponding to intensity of pain. The distance between the starting point (the right end) to the patient mark, in centimeters, is recorded as his/her pain score.
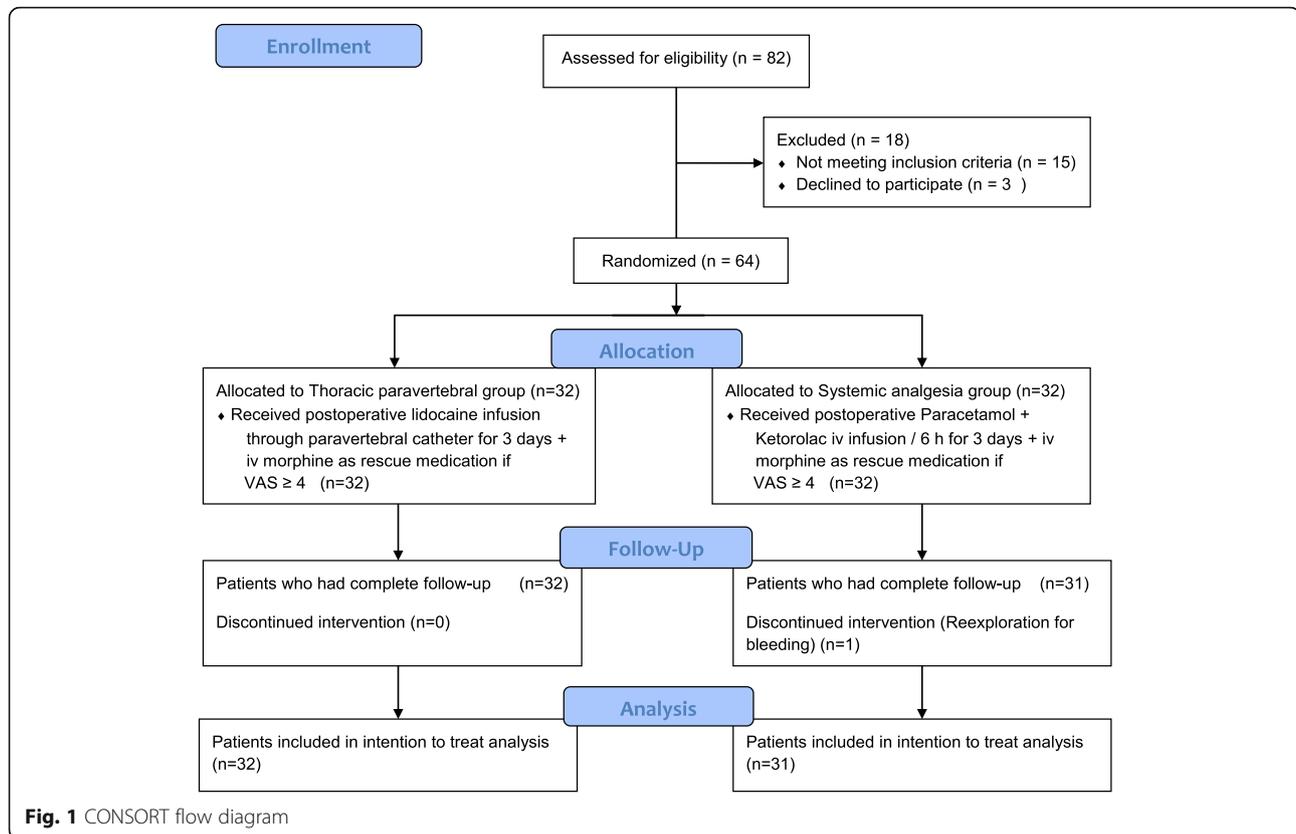
Also, patients were instructed in the use of Microspiro HI-198 (Chest Corporation, Tokyo, Japan). After training, forced vital capacity (FVC), forced expiratory volume in 1 s (FEV$_1$), and peak expiratory flow rate (PEFR), in the sitting position, were recorded in the day before surgery.

Anesthesia

Anesthetic technique was standardized for all patients. Patients were premedicated with IV injection of glycopyrrolate 0.01 mg/kg. Anesthesia was induced with intravenous 1.5–2 mg/kg propofol and fentanyl 2 μg/kg. Intravenous atracurium 0.5 mg/kg was given to facilitate tracheal intubation. Anesthesia was maintained with isoflurane 0.8–1.2% in 100% oxygen, incremental doses (0.1 mg/kg) of atracurium, and mechanical ventilation. At the end of surgical operation, neuromuscular block was reversed using IV neostigmine 2.5 mg and glycopyrrolate 0.01 mg/kg.

Technique of intraoperative paravertebral catheter insertion

We used the technique that was described by Sabanathan et al. in 1988 [14] and modified by them in 1990 [15]. After completing the surgical pulmonary procedure and with the chest is still open, starting from the posterior end of the thoracotomy, parietal pleura is raised from the posterior chest wall to the vertebral body and for two spaces above and below the incision of thoracotomy creating a pouch. A 16-gauge disposable Tuohy needle is inserted percutaneously through a low posterior interspace. The needle is advanced until the tip appeared in the created pouch. The stylet is removed, and a 16-gauge side-holed epidural catheter is advanced into the created pouch, and the needle is withdrawn. Using a curved forceps, a small defect is done in the extrapleural fascia to be directly in the paravertebral space. The

Fig. 1 CONSORT flow diagram

cannula is passed to the paravertebral space through the defect and advanced cranially for 2 to 3 cm. The parietal pleura is reattached to the posterior edge of the wound, and the catheter is secured. Then, a bolus dose 15–20 ml of 1% lidocaine is injected through the catheter, and the chest is closed as usual with one or two intercostal drainage tubes according to the surgical procedure.

Protocol of analgesia

All patients, in both groups, received intravenous analgesia with 1 g paracetamol and 30 mg ketorolac half an hour before the end of surgery.

Systemic analgesia (SA) group continues to receive 1 g paracetamol and 30 mg ketorolac by intravenous infusion every 6 h for 3 days. Thoracic paravertebral block (TPVB) group received continuous infusion of 0.1 ml/kg/h of 1.0% lidocaine (l mg/kg/h) using infusion pump through the inserted paravertebral catheter for 3 days. Intravenous morphine sulfate (0.05 mg/kg) was given as a rescue medication if the VAS ≥ 4 for both groups. A senior nurse was responsible for handling the analgesia regimen, and another nurse was responsible for recording pain score on visual analogue scale (VAS) and morphine consumption, as scheduled.

Objective pulmonary function

Forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), and peak expiratory flow rate (PEFR) were measured in the sitting position 24, 48, and 72 h postoperatively for all patients. Results were expressed as a percentage of the preoperative values that were done in the day before surgery.

End points

The primary end point was pain score on visual analogue scale (VAS) at rest and on coughing measured and recorded at 1, 6, 12, 24, 36, 48 h, and 72 h postoperatively. The secondary end points were total morphine consumption at the end of each postoperative day and pulmonary function tests at 24, 48, and 72 h postoperatively. Complications related to the catheter, postoperative pulmonary complications, respiratory depression (defined as respiratory rate less than 8 per min), nausea and vomiting, and urinary retention were recorded.

Statistical analysis

Continuous variables are presented as mean ± SD and categorical variables as number and percent. Continuous variables were compared using t test or Mann–Whitney test if not normally distributed, and categorical variables

Table 1 Characteristics of patients and surgical procedures

Characteristics	TPVB group ($n = 32$)	SA group ($n = 31$)	P value
Age (years)	48 ± 14	46 ± 11	0.53
Male	19 (59.4%)	17 (54.8%)	0.72
ASA II	22 (68.8%)	23 (74.2%)	0.62
ASA III	10 (31.2%)	8 (25.8%)	0.62
BMI (kg/m^2)	29 ± 5	28 ± 6	0.47
Type of surgery			
Wedge resection	6 (18.8%)	7 (22.5%)	0.71
Segmentectomy	3 (9.4%)	2 (6.5%)	0.81
Metastasectomy	2 (6.2%)	2 (6.5%)	0.71
Lobectomy	19 (59.4%)	18 (58%)	0.56
Pneumonectomy	2 (6.2%)	2 (6.5%)	0.71
Side of the procedure			
Left thoracotomy	18 (56.2%)	19 (61.3%)	0.68
Right thoracotomy	14 (43.8%)	12 (38.7%)	
Duration of surgery (min)	108 ± 44	98 ± 46	0.38

Continuous variables are presented as mean ± SD and categorical variables as number and percent

TPVB thoracic paravertebral block, *SA* systemic analgesia, *ASA* American Society of Anesthesiologists physical status, *BMI* body mass index

were compared using the chi^2 test or Fischer's Exact test if the frequency of the events is less than 5. Differences were accepted to be significant at $p < 0.05$. Analyses were done using IBM SPSS for Windows, Version 22.0 (IBM Corp., USA).

Results

Sixty-three adult patients included in the study, 32 in thoracic paravertebral block (TPVB) group and 31 in systemic analgesia (SA) group, 36 males and 27 females. There were no significant differences between both groups regarding age, sex, ASA class, BMI, side, type, and duration of operation (Table 1).

Pain relief

Pain scores on visual analogue scale were significantly lower in TPVB group at rest and on coughing throughout the study period, indicating better pain relief in the TPVB group (Tables 2 and 3).

In addition, postoperative morphine consumption was significantly lower in TPVB group of patients in all the three postoperative days (Table 4).

Postoperative pulmonary function

In both groups, all pulmonary function tests (FVC, FEV$_1$, and PEFR) were reduced in first postoperative day (measured 24 h postoperatively) than the preoperative values and continue to increase in the second and third days but not reaching the preoperative values at 72 h postoperatively. But, all pulmonary function tests are significantly better in TPVB group in all days (Table 5).

Complications and side effects

No complications could be attributed to the paravertebral catheter or to lidocaine. Pulmonary complications were more in SA group but without statistical significance ($P = 0.14$) (Table 6). Side effects were significantly more in SA group ($P = 0.03$). The most frequent side

Table 2 Pain score on visual analogue scale at rest

	TPVB group ($n = 32$)	SA group ($n = 31$)	P value
VAS 1 h	4.1 ± 1.1	5.2 ± 1.3	< 0.001
VAS 6 h	3.0 ± 1.3	4.2 ± 1.5	0.001
VAS 12 h	2.9 ± 1.1	4.1 ± 1.3	< 0.001
VAS 24 h	2.0 ± 1.3	3.4 ± 2.0	0.002
VAS 36 h	1.8 ± 1.3	3.0 ± 2.0	0.008
VAS 48 h	1.6 ± 0.7	2.3 ± 0.8	< 0.001
VAS 72 h	1.1 ± 0.6	1.8 ± 0.8	< 0.001

TPVB thoracic paravertebral block, *SA* systemic analgesia, *VAS* visual analogue score of pain, presented as mean ± SD, *h* postoperative hour

Table 3 Pain score on visual analogue scale on coughing

	TPVB group ($n = 32$)	SA group ($n = 31$)	P value
VAS 1 h	6.0 ± 1.2	7.2 ± 1.5	0.001
VAS 6 h	4.0 ± 1.1	5.2 ± 1.3	< 0.001
VAS 12 h	3.9 ± 1.0	4.8 ± 1.4	0.006
VAS 24 h	3.7 ± 0.9	4.5 ± 1.3	0.008
VAS 36 h	3.3 ± 0.9	3.8 ± 1.0	0.041
VAS 48 h	2.0 ± 0.8	2.6 ± 0.9	0.007
VAS 72 h	1.7 ± 0.8	2.2 ± 0.8	0.016

TPVB thoracic paravertebral block, *SA* systemic analgesia, *VAS* visual analogue score of pain, presented as mean ± SD, *h* postoperative hour

Deebis *et al. The Cardiothoracic Surgeon*   (2020) 28:17

Page 5 of 7

Table 4 Postoperative morphine consumption daily for each group

	TPVB group (n = 32)	SA group (n = 31)	P value
Day 1 (mg/day)	20.1 ± 11.1	37.2 ± 19.1	< 0.001
Day 2 (mg/day)	12.2 ± 8.8	27.4 ± 18.4	< 0.001
Day 3 (mg/day)	9.7 ± 6.2	15.2 ± 11.8	0.028

Total morphine consumption every day presented as mean ± SD
TPVB thoracic paravertebral block, *SA* systemic analgesia

effects were nausea and vomiting (6 patients in SA group and 1 patient in TPVB group, P = 0.04). Urinary retentions were more in SA group but without statistical significance (P = 0.32) (Table 6).

Discussion

Postthoracotomy pain is reported as one of the most painful postoperative pain and frequently causes significant morbidity [1]. Combinations of analgesic drugs that have different mechanisms of action achieve a synergistic effect with better postoperative pain relief and fewer side effects [17]. A meta-analyses of randomized trials concluded that paracetamol (acetaminophen) in combination with a nonsteroidal anti-inflammatory drug for postoperative pain control achieved better pain relief than each drug alone, and this combination decreased opioid use [18]. According to the above concept, we used a multimodal systemic analgesia in the form paracetamol combined with ketorolac (nonsteroidal anti-inflammatory drug) plus morphine as a rescue medication for systemic (SA) analgesia group in this study.

Thoracic paravertebral space is a wedge-shaped space on both sides of vertebral column. Parietal pleura forms the anterolateral boundary of the space. Vertebrae and intervertebral foramina form its medial boundary. The space contains intercostal nerves (spinal nerves) and its posterior primary rami, the rami communicantes, and the sympathetic chain. The spinal nerves in the space formed from small bundles without enclosing fascial sheath making them highly susceptible for blockade with local anesthetics [11].. The injected local anesthetic drug in the paravertebral space diffuses cranially and caudally covering several segments resulting in unilateral somatic and sympathetic nerve block [13]. The conventional technique for TPVB is the percutaneous technique that may be aided with ultrasonic guidance or nerve stimulation with about 6 to 19% failure rate and a complication rate of 2.6 to 5% in the form of pneumothorax, vascular injury, Horner syndrome, and epidural or intrathecal spread [11]. Intraoperative insertion of the paravertebral catheter under direct vision into the paravertebral space is an alternative technique that can be done easily by the surgeon [14, 15]. Results of this study and that of many other studies [3, 14–16, 19–22] supported that this technique is an easy and safe and without complications related to catheter insertion.

The most commonly used local anesthetic drugs for continuous paravertebral block are bupivacaine, lidocaine, and ropivacaine. Bupivacaine and ropivacaine are long-acting local anesthetic drugs, while lidocaine is a short-acting one with a shorter half-life. So, for continuous infusion, lidocaine may be the better choice [20, 21, 23, 24]. Watson et al. [20] in a study comparing bupivacaine versus lidocaine for continuous paravertebral block after thoracotomy reported that their efficacy was equivalent with lesser risk of systemic toxicity for lidocaine. Also, Ghisi et al. [23] reported equal analgesic effect of lidocaine and ropivacaine for continuous paravertebral block, but they recommended the use of lidocaine because of its easier titratability and lower cost. As the results of this study, many investigators [16, 20, 21, 23, 24] used lidocaine for continuous paravertebral block without side effects related to the drug. Many studies [2, 4, 6, 9, 10] comparing postthoracotomy TPVB to epidural analgesia reported equivalent pain relief with lesser side effects of TPVB. TPVB is superior compared to pure intercostal nerve block in postthoracotomy pain relief as TPVB also blocks posterior primary rami and sympathetic fibers [22].

Table 5 Postoperative changes in pulmonary function tests (expressed as a percent of preoperative values)

Pulmonary function test	Time of test	TPVB group (n = 32)	SA group (n = 31)	P value
Forced vital capacity (FVC), mean ± SD	24 h	54 ± 9	26 ± 12	< 0.001
	48 h	65 ± 11	33 ± 13	< 0.001
	72 h	70 ± 12	46 ± 10	0.007
Forced expiratory volume in 1 s (FEV1), mean ± SD	24 h	60 ± 10	29 ± 12	< 0.001
	48 h	71 ± 12	36 ± 11	< 0.001
	72 h	76 ± 11	48 ± 10	0.003
Peak expiratory flow rate (PEFR), mean ± SD	24 h	58 ± 11	28 ± 11	< 0.001
	48 h	69 ± 14	38 ± 12	< 0.001
	72 h	75 ± 12	49 ± 13	0.001

Pulmonary function tests (expressed as a percent of preoperative values) presented as mean ± SD
TPVB thoracic paravertebral block, *SA* systemic analgesia

Deebis *et al. The Cardiothoracic Surgeon*　　(2020) 28:17

Page 6 of 7

Table 6 Postoperative complications and side effects

	TPVB group (*n* = 32)	SA group (*n* = 31)	*P* value
Postop. pulmonary complications			
Prolonged air leak	1	2	0.49
Atelectasis	0	2	0.24
Pneumothorax	1	1	0.75
Bronchospasm	0	1	0.49
Pleural effusion	1	1	0.75
Total pulmonary complications	3 (9.4%)	7 (22.6%)	0.14
Postop. side effects			
Nausea and vomiting	1	6	0.04
Urinary retention	2	4	0.32
Respiratory depression	0	0	
Total side effects	3 (18.7%)	10 (54.8%)	0.03

Categorical variables are presented as number and percent

TPVB thoracic paravertebral block, *SA* systemic analgesia, *Postop.* postoperative

This study demonstrates significant pain relief in TPVB group compared to SA group supported by lower pain score on visual analogue scale at rest and on coughing and lesser morphine consumption. Marret et al. [25] comparing TPVB with ropivacaine to systemic analgesia and Fortier et al. [3] comparing 3 analgesic modalities (systemic analgesia, continuous wound catheter analgesia, and continuous thoracic paravertebral block with ropivacaine) demonstrated the superiority of TPVB for postthoracotomy pain relief with lesser morphine consumption as the results of our study. This study confirms the findings of other studies that there are marked alteration of pulmonary function following thoracotomy [11, 26, 27], and effective postoperative regional analgesia as thoracic paravertebral block and thoracic epidural block reduces this alteration and aids in its recovery [11, 16, 22, 24, 26]. This study recorded no significant difference in postoperative pulmonary complications between TPVB group and SA group. Nausea and vomiting were significantly more in SA group, and this is mostly due to increased morphine consumption in that group as postoperative nausea and vomiting are strongly influenced by postoperative opioid use in a dose-related manner [28, 29]. Many studies [8, 16, 22, 30] comparing TPVB with continuous local anesthetic perfusion versus intravenous or intramuscular opioids for postoperative analgesia reported better pain relief and lesser side effects in TPVB patients.

Limitations

As there were different routes of administration of analgesic drugs for each group of patients, it was very difficult to keep double blindness. Also, the number of patients can be considered as another limitation.

Conclusion

This study demonstrates that patients receiving continuous paravertebral block with lidocaine via a catheter inserted with direct access to the thoracic paravertebral space by the surgeon intraoperatively have significantly better pain relief with fewer side effects and better restoration of pulmonary functions compared to patients receiving systemic analgesia, and this technique (Sabanathan's technique) is safe and reliable as a method for postthoracotomy analgesia.

Deebis *et al. The Cardiothoracic Surgeon* (2020) 28:17

Page 7 of 7

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