Original Article

Ultrasound-guided bilateral superficial cervical plexus block for thyroid surgery: The effect of dexmedetomidine addition to bupivacaine-epinephrine

ABSTRACT

Background: The thyroid gland surgery is a common and painful procedure demanding analgesia. Many regional techniques are applied for anterior neck surgeries mostly assigned in relation to the involved cervical fascia. Dexmedetomidine (Precedex) is a selective alpha 2 adrenoceptor agonist which prolongs the sensory blockade duration of local anesthetics. Our study hypothesis is that ultrasound (US)-guided bilateral superficial cervical plexus block (BSCPB) may provide longer analgesia when adding dexmedetomidine to bupivacaine-epinephrine.

Purpose: The aim of this study is to evaluate the analgesic efficacy and possible side effects of US-guided BSCPB and the effect of dexmedetomidine addition to bupivacaine-epinephrine in patients undergoing thyroid surgery.

Methods: This prospective, double-blind, randomized study was performed on 42 patients randomized into two equal groups each of 21; bupivacaine Group B and dexmedetomidine Group D. Patients with contraindications to regional anesthesia or uncontrolled comorbidities were excluded from the study. Total pethidine consumption in 24 h is the primary outcome. The visual analog scale, timing of the first opioid request, and hemodynamics are the secondary outcomes.

Results: In Group D, there was a longer time to the first request of opioid postoperatively, a lower total pethidine consumption and pain score postoperatively, and lower fentanyl requirements intraoperatively.

Conclusions: Sonographic-guided bilateral SCPB using a combination of bupivacaine, dexmedetomidine, and epinephrine was superior to bupivacaine for prolonged analgesia with less intra- and postoperative opioid consumption and lower side effect profile during thyroid surgery.

Key words: Dexmedetomidine; superficial cervical plexus block; thyroid surgery; ultrasound

Introduction

The thyroid gland surgery is a common and painful procedure demanding analgesia.[1] The skin overlying the neck, ear, angle of the mandible, shoulder, and clavicle is supplied by the superficial cervical plexus (SCP), which is a sensory neural plexus formed from the ventral rami of the first four cervical nerves (C1–C4). It emerges behind the posterior border of sternomastoid muscle.[2]

The cervical plexus includes also deep branches to the neck muscles and the phrenic nerve (C3, C4, and C5) in addition to

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communicating branches to the superior cervical sympathetic ganglion, hypoglossal, and spinal accessory nerves.[3]

Many regional techniques were applied for anterior neck surgeries mostly assigned in relation to the involved cervical fascia. This fascia greatly affects local anesthetic (LA) distribution along nerves.[4] A subcutaneous infiltration of LA under the skin,[5] superficial to the investing fascia is called superficial block.[6] Injection deep into the investing fascia is the intermediate cervical block as a correct name instead of superficial block.[7] In the intermediate block, the injection is between the superficial and deep (prevertebral) fascia while the deep block is under the deep cervical fascia.[8] Bilateral deep cervical plexus block (CPB) carries the risk of phrenic nerve block, with subsequent ventilatory hazards.[9]

The intermediate CPB is simple and easy technique; however, its use blindly has controversial efficacy as some studies proved effectiveness.[1,10] While others found noneffectiveness.[6,11]

Dexmedetomidine (Precedex®, Hospira) is a selective alpha-2 adrenoceptor agonist which is used as a sedative and analgesic; it prolongs the sensory blockade duration of LAs.[12] Dexmedetomidine 0.5 mcg/kg has prolonged the duration of analgesia of 0.5% ropivacaine by nearly 75%.[13] In addition, it shortens the sensory block onset time with more hemodynamic stability and higher Ramsey's sedation score.[14]

Our study hypothesis is that ultrasound (US)-guided bilateral SCP block (BSCPB) may improve intra- and postoperative analgesia when adding dexmedetomidine to bupivacaine-epinephrine during thyroid surgery.

Aim of the work

The aim of this study is to evaluate the analgesic efficacy and possible side effects of US-guided BSCPB and the effect of dexmedetomidine addition to bupivacaine-epinephrine in patients undergoing thyroid surgery.

Sample size

Sample size was calculated using *a priori* power analysis of G*power 3.1 to analyze the difference between two-independent equal groups, with effect size 0.8 to achieve a power of 80%, yielding a total sample size of 42 (21 patients in each group), with alpha error 0.05.

The patients

This prospective, double-blind, randomized study was performed at Oncology Center-Mansoura University. After approval of the institutional review board with code number (R133), clinical trial registry number (PACTR201611001878340) at Pan African clinical trial registry. Patient consent was taken after explanation of the procedure and visual analog scale (VAS). Patients were blindly randomized using sealed envelopes without sex stratification into two equal groups each of 21 patients:

- The bupivacaine group B – the anesthetic cocktail contained 10 ml bupivacaine 0.35% with 5 mcg/ml epinephrine for each side
- The dexmedetomidine group D – the anesthetic cocktail contained 10 ml bupivacaine 0.35% with 5 mcg/ml epinephrine plus dexmedetomidine 40 μg (mcg) for each side.

There were no reported interactions when mixing those three medications (bupivacaine, epinephrine, and dexmedetomidine in one syringe) or any reported major or minor drawbacks. The dose of dexmedetomidine is based on a study implementing a blind combined superficial and deep CPB with ropivacaine with dexmedetomidine in a dose of 1 mcg/kg.[14] Furthermore, a recent meta-analysis by Abdallah and Brull demonstrated that perineural dexmedetomidine was used in a range of doses between 30 and 100 mcg.[15]

The inclusion criteria were patients scheduled for elective thyroid surgery including goiters, tumors, and cysts with euthyroidism confirmed with thyroid function tests (TSH, free triiodothyronine, and thyroxin). Patients American Society of Anesthesiologists I and II status of either sex aged between 25 and 65 years old. The exclusion criteria were the patient refusal, infection at the puncture site, severe hypertension or any severe systemic illness, allergy to LAs, preexisting peripheral nerve neuropathies, substernal goiter, probable cervical lymph node dissection, language barrier, pregnancy, and previous cervical surgery.

Methods

An independent anesthesiologist not participating in this study or data collection read the number contained in the envelope and prepare the anesthetic cocktail according to the assigned group. Another anesthesiologist managed the anesthesia to patients participating in the study. Before induction of general anesthesia, standard monitors were placed. Induction of anesthesia was carried out using propofol 1–2 mg/kg, atracurium 0.5 mg/kg, and fentanyl 1 mcg/kg. Maintenance using isoflurane 1.2% and atracurium increments was done as required.

The SCP was performed under anesthesia in a supine position, with the head turned to either side for the bilateral block. The ultrasound screen was contralateral to the clinician,

and the ultrasound transducer directional marker is medial. Under complete aseptic technique, a high-frequency linear transducer (6–13 MHz– Siemens, ACUSON P300™ ultrasound system) is placed in a transverse plane on the anterior neck at the level of the midpoint of the line connecting the mastoid process with the insertion of the sternal head of sternocleidomastoid muscle (SCM). The goal is to guide the needle tip from lateral to medial direction just under the tapering posterolateral edge of the SCM to the fascial plane under the SCM and just above the levator scapulae muscle. After aspiration test, the LA injection should be visualized.[16]

Heart rate (HR), mean arterial blood pressure (MBP), and oxygen saturation (SaO_2) were assessed preoperatively and every 30 min intraoperatively then postoperatively at 2, 4, 6, 8, 16, and 24 h. Intraoperative increase in HR or MBP more than 20% was managed by giving increments of 25 mcg fentanyl intravenously; total needs were recorded.

Postoperative pain was assessed using a 0–10 VAS at 2, 4, 6, 8, 16 and 24 h. All patients received paracetamol 1 g intravenously every 8 h. Pethidine 25 mg was administered intravenously if the VAS is 3 or higher.

The primary outcome was the total pethidine consumption during the first24 h period. Secondary outcomes were pain scores, timing of the first opioid request, also possible side effects including hematoma, nausea, vomiting, and hoarseness of voice or nerve injury. Metoclopramide was used as an antiemetic or ondansetron for repeated vomiting.

Statistical methods

Data analysis was performed using SPSS statistical package version 17 (SPSS, Inc., Chicago, IL, USA). The data were examined for normal distribution using Kolmogorov–Smirnov test. Continuous and parametric data were displayed as mean ± standard deviation, while continuous nonparametric or categorical data as percentages. Student *t*-test for quantitative data and paired sample *t*-test for significant differences in one group. VAS scores were assessed using one-way analysis of variance with repeated measures followed by Tukey's *post hoc* test. For nonparametric data, Mann–Whitney test is used. Chi-square test is used for qualitative data. $P < 0.05$ is considered statistically significant.

Results

In this study, 52 patients were included, while the analyzed patients were 42 as illustrated in the flow chart [Figure 1].

The demographic data of patients showed no significant difference among the studied groups [Table 1].

The time to the first request of opioid analgesia showed a significant increase in Group D compared with Group B. The total pethidine consumption postoperatively and the amount of intraoperative fentanyl requirements were also significantly lower in Group D compared with Group B [Table 2].

There was no significant change in the incidence of postoperative complications between the studied groups [Table 3].

The postoperative VAS was lower in Group D compared to Group B, and this difference was significant ($P = 0.001$) from 6 h up to 16 h postoperatively [Figure 2].

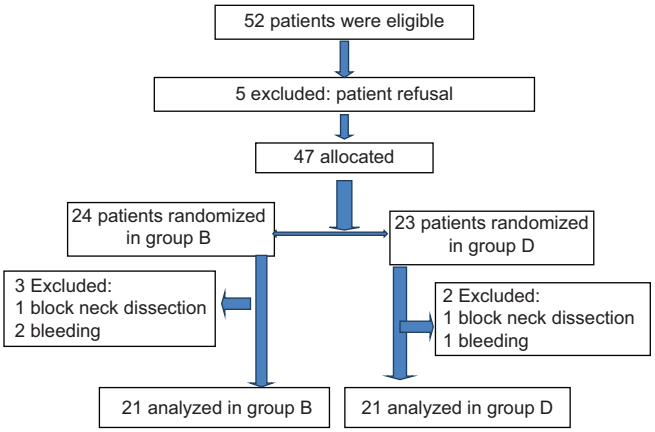

Figure 1: Consort flow chart of the studied patients

Table 1: Demographic data

	(*n*=21)		*P*
	Group B	Group D	
Age (year)	44±22	38±20	0.45
Gender (male: female) (%)	3:18 (14:86)	5:16 (24:76)	0.93
Weight (kg)	48±10	52±10	0.53
Operative time (min)	97±42	90±57	0.66
	Group B, *n* (%)	Group D, *n* (%)	*P*
ASA class			
I	14 (66)	15 (71)	0.91
II	7 (33)	6 (29)	0.87

Data are in mean±SD (*n*=21). ASA: American Society of Anesthesiologists; SD: Standard deviation

Table 2: Analgesia data regards: First request, intra- and postoperative analgesic consumption

	Group B	Group D	*P*
Time to first opioid request (min)	339±81	891±113*	0.0001
Postoperative pethidine (mg)	159±34	94±41*	0.0001
Intraoperative fentanyl (mcg)	150±36	105±26*	0.0001

*Significant between the two groups. Data are in mean±SD (*n*=21). SD: Standard deviation

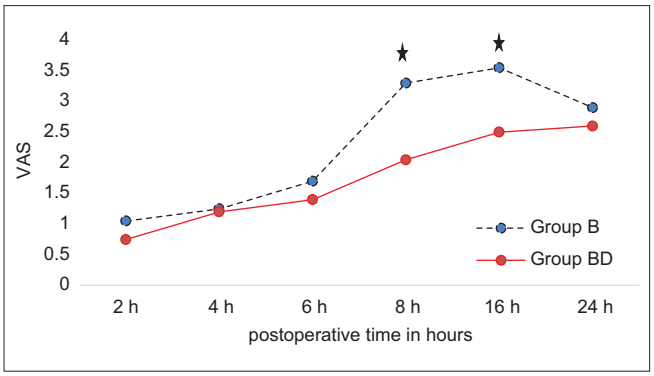

Figure 2: Postoperative mean visual analogue scale for the studied groups. Significant difference between Group B and D. *P* < 0.05

Table 3: Postoperative incidences of complications in number and percentage (*n*=21)

	Group B, *n* (%)	Group D, *n* (%)	*P*
Nausea	4 (19)	3 (14)	0.68
Vomiting	3 (14)	2 (9)	0.64
Antiemetic use	4 (19)	3 (14)	0.68
Hoarseness of voice	5 (24)	4 (19)	0.87
Horner syndrome	None	None	-
Transient discomfort or throat pain	21 (100)	21 (100)	1

There was no significant difference in MBP between the studied groups [Figure 3]. The HR was significantly lower in Group D compared with Group B at 60, 75.90 and 105 min, respectively [Figure 3].

Discussion

Our study showed that sonographic-guided bilateral SCPB using bupivacaine with dexmedetomidine and epinephrine extended the analgesia and decreased opioid requirement intraoperatively and postoperatively. That has been confirmed recently.[13,14]

A lot of techniques were implemented to alleviate postoperative pain after thyroid surgery including systemic opioids, nonsteroidal anti-inflammatory drugs, SCPB, and deep CPB that was performed in almost all the studies blindly using the anatomical landmarks. Data were still conflicting for the use of bilateral SCPB in thyroid surgery. That conflicting data may be attributed to the use of blind injection with variable success rate and higher incidence of failure rate owing to the instillation of LA away from the SCP which lies directly under the platysma muscle. Sometimes the platysma cannot be felt while piercing it, especially in females which increase the failure rate with the blind technique.

These results confirm the analgesic effects of US-guided bilateral SCPB against the controversy reported before,

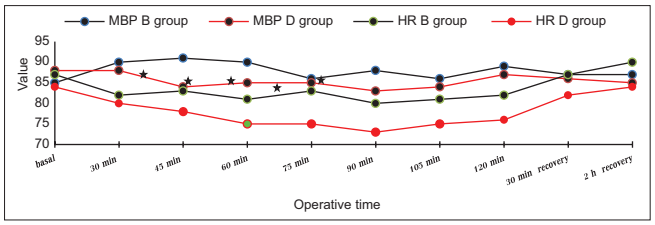

Figure 3: Mean arterial blood pressure in mmHg and heart rate in beat/min of the studied groups. Large dots = significant difference in heart rate with basal in Group D. Significant difference in heart rate between Group B and Group D

that may be attributed to the blind technique in addition to the difference in the concentration, the volume (5–20 ml) and type of LA, the timing of the technique (pre- and postoperative), the depth of injection, the 1 or 3 points manner, and finally the nonincision-related pain sources such as pharyngeal, laryngeal, muscular, and vertebral pain.[6,11,13,17] The US-guidance remains the only reliable tool for performing a CPB,[18] providing faster onset and longer duration of the block, reduces the performance time, and reduces the complications (vascular puncture).[19] In addition to reduced LA requirements.[20] However, other opinion, US guidance does not increase the success rate of this block compared with landmark technique (80% vs. 85%).[21]

The use of dexmedetomidine markedly reduced the pain when added to bupivacaine, and this was effective up to 16 h postoperatively. This was reflected by a marked prolongation of the timing of the 1st opioid request to alleviate pain (pethidine) in our study with an average request at (891 ± 113) minutes in Group D. Moreover, the total pethidine consumption was markedly reduced in Group D during the postoperative period (94 ± 41 mg). Furthermore, the dose of intraoperative fentanyl requirements was reduced in Group D (105 ± 26 mcg). Our results are in agreement with Santosh and Mehandale, but they were using ropivacaine 20 ml 0.5% plus dexmedetomidine 0.5 mcg/kg in blinded bilateral SCPB. They reported prolonged analgesia by nearly 75% (28 h in dexmedetomidine group vs. 16 h in control group).[13] Another study,[14] using blind combined superficial and deep CPB with 30 mL of 0.375% ropivacaine plus 1 mcg/kg of dexmedetomidine showed the prolonged duration of analgesia and extended sensory block with more hemodynamic stability and more sedation in dexmedetomidine group.

Dexmedetomidine has an antisympathetic central role plus activating the vagus nerve that lower the plasma catecholamine levels thus provide stable hemodynamics which lower blood pressure and HR.[14] The mechanism of perineural dexmedetomidine mainly results from the activation of the sodium–potassium pump leading to enhancement of membrane hyperpolarization.[22,23]

In this study, the decrease in HR in dexmedetomidine group is attributed to the alpha-2 adrenoreceptor agonist plus the sedative effects reducing the HR during and after anesthesia.

Anatomically, three types of nerves are involved in the efficacy SCPB; sensory, motor, and visceral. The sensory nerves are blocked during subcutaneous and intermediate CPB, SCPB alone may be inadequate solely for thyroidectomy as the motor and visceral nerves are not blocked.[24] The SCPB theoretically blocks the sensory nerves,[25] while deep CPB would block the motor nerves. Actually, the intermediate CPB may involve the ansa cervicalis,[26] that is, embedded in the anterior wall of the carotid sheath, providing motor supply to the strap muscles, but CPB do not block neither the platysma nor SCM. Platysma can be desensitized through infiltration of the cervical branch of facial nerve upward along the anterior border of SCM.[24] Ramachandran *et al*. showed that superficial and intermediate CPBs are equally effective.[27] ddition, a cadaver dye study reported that the superficial and deep cervical spaces may communicates.[26] Moreover, a radiological study confirmed successful spread of the LA from the interfacial space to deep cervical plexus[4] that may explain the similar efficacy of superficial and deep cervical blocks in inducing motor block.[25]

The risk of phrenic nerve block is high with deep CPB reaching 61%, so bilateral deep blocks are contraindicated in vulnerable patients.[28] Our results showed no breathing difficulty, that is in agreement with data showing 0% phrenic nerve palsy when US-guided bilateral SCPB was implemented.[29] Functionally, It may be logic if deep cervical fascia is impermeable as shown in a cadaver study,[30] or when phrenic nerve completely originates from the brachial plexus that occurs in up to 20% of cases.[31] However, there is still a risk of phrenic block, as the LA injected in intermediate cervical block can permeate deeply to the phrenic nerve.[26]

Our results showed no Horner syndrome development. However, this syndrome was reported after SCPB involving the ipsilateral cervical sympathetic chain. The incidence was as low as (4%)[32] to (37%) using sonographic guidance for SCPB.[29]

Hoarseness of voice was detected in 24% and 19% in our patients. Regarding the complications reported with SCPB such as hoarseness of voice, when using US-guided SCPB, the incidence of hoarseness was variable, ranging from 4%,[32] 28%,[33] up to 72%.[29] This may be explained by the difference in LA concentrations or the injection close to the carotid artery, Infiltration of the vagus nerve (close to carotid sheath) can lead to temporary paralysis of the ipsilateral recurrent laryngeal nerve with resultant temporary paralysis of the vocal cord. If this occurs, it is possible that patients may feel confused with the hoarseness and inability to swallow.[34] Therefore, a lower volume and concentration of LA may be safer for paracarotid infiltration.[29] To minimize the risk of complications of the SCPB, several precautions should be taken such as awareness of the anatomy, ensuring to stay at the level of C4, shallow injection just under the SCM belly; and appropriate anesthetic volumes (2–5 mL).[35]

Our results showed no significant difference in MBP between both groups. Group D showed significantly lower HR compared to Group B. Lin *et al*. showed more hypotension, bradycardia, and sedation with dexmedetomidine using 1 mcg/kg in contrast to 0.5 mcg/kg in our study.[14] Hence, limiting dexmedetomidine dose to 0.5 mcg/kg may reduce the undesirable hemodynamic effects.[13]

Pharmacologically, dexmedetomidine offers a sympatholytic effect while activating the vagus nerve; it has a dose-related inhibition for blood pressure and HR providing stable hemodynamics.[14] Furthermore, the diffusion of the LA along the carotid sheath may produce vagal blockade that results in attenuation of the baroreceptor reflex, subsequently an autonomic imbalance, and increases in BP and HR.[36]

Epinephrine is one of the oldest additives to LAs solutions with a recommended dosing of 0.5–1.0 μg/kg in a concentration of 5–10 μg/mL.[37]

In addition to its vasoconstrictive actions, it also seems to have intrinsic antinociceptive properties mediated by alpha-2 adrenoreceptor activation.[38]

The effect of epinephrine in peripheral blocks seems to be largely dependent on its vasoconstrictive action as perineural epinephrine alone does not seem to cause any sensory or motor block.[39]

The addition of epinephrine provides prolongation of analgesia through reducing LAs absorption and decreasing its toxicity.[40] Patient anxiety and systemic absorption of epinephrine are associated with increased HR.

However, dexmedetomidine predominated and displayed significant bradycardia in this study. One patient in this study complained of earlobe numbness (2%) that was resolved after 12 h postoperatively. The incidence of facial palsy was (5%)[32] to 13% in another study.[29]

In this study, the incidence of vomiting was (14% in Group B vs. 10% in Group D) while the incidence of nausea

was 19% in Group B versus 14% in Group D. The antiemetic (primpiran 10 mg IV) was given for all patients complaining of nausea or vomiting, and it was effective in abolishing this problem. Several other studies showed no benefit from bilateral SCPB in reducing nausea and vomiting.[11,41] Only Suh *et al*. observed the reduction of nausea and vomiting.[1]

Patients in both groups complained of discomfort or throat pain in the immediate postoperative period which increased in intensity during deglutition. Later, it was evident only on deglutition, which lasted for few hours. Our observation indicates that when patients were not concerned about incision pain, they paid more attention to the pain on deglutition. Unfortunately, SCPB was ineffective in combating throat pain. However, the pain lasted only a few hours (3–5 h) after extubation and patients did not demand additional analgesics. This outcome corroborates with the earlier findings that postintubation discomfort lasted only for a short duration and was of mild intensity not requiring additional analgesics.[42]

Conclusions

Sonographic-guided bilateral SCPB using combination bupivacaine, dexmedetomidine, and epinephrine was superior to bupivacaine–epinephrine with more prolonged analgesia and less opioid consumption in association with low side effect profile during thyroid surgery.

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Conflicts of interest
There are no conflicts of interest.

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