A spray-as-you-go airway topical anesthesia attenuates cardiovascular responses for double-lumen tube tracheal intubation

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Research Article

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Abstract

Background: The spray-as-you-go airway topical anesthesia and nerve block technique are commonly used in awake tracheal intubation. However, their effects have not been described for double-lumen tube intubation. A prospective randomized study was designed to compare their intubation effects in thoracic surgery patients.

Methods: Sixty-six ASA physical status I and II patients were scheduled to undergo double-lumen tube(DLT) tracheal intubation for thoracic surgery. They were randomly assigned into control (Group C), ultrasound (Group U), and flexible intubation scope (Group F) groups with 22 cases in each group. Patients in Group C were induced with a standard anesthetic regimen. Patients in Group U and Group F were treated with superior laryngeal nerve(SLN) block combined with transtracheal injection and given a spray-as-you-go airway topical anesthesia respectively before intubation. Hemodynamic variables during intubation were recorded. Additional patient data were recorded including the occurrence of adverse events, the level of hoarseness, the occurrence of sore throat, memory function and the level of patient satisfaction with anesthesia.

Results: The blood pressure and heart rate of patients in group C significantly increased 1 min after tracheal intubation ($P<0.05$) compared to before anesthesia yet the blood pressure and heart rate of patients in Groups U and F remained stable. During observation, there were 10 cases of hypertension in Group C, 6 cases in Group U and 1 case in Group F. In Group C, tachycardia was observed in 9 patients along with 9 cases in Group U and 4 cases in Group F. In Group U, 4 patients experienced puncture and bleeding were and 8 patients had a poor memory of transtracheal injection. No significant differences were found in the incidence of hoarseness, sore throat, and satisfaction with anesthesia in postoperative follow-up.

Conclusions: Spray-as-you-go airway topical anesthesia and SLN block combined with transtracheal injection technique can inhibit the cardiovascular response during DLT tracheal intubation. The spray-as-you-go technique has fewer complications and more advantages compared to other approaches.

Background

In thoracic surgery, general anesthesia with DLT tracheal intubation is commonly used to achieve single-lung ventilation that is required during the operation [1]. Due to the large diameter, length, and hard texture of the DLT, strong stimulation of the tube induced fluctuations in hemodynamics can increase the incidence of cardiovascular adverse events [2, 3]. Approaches to reduce stress during DLT tracheal intubation have been a focus of clinical research. Vasoactive drugs and anesthetics are commonly used to inhibit the stress response during intubation [4] yet the optimum dosing of these drugs remains challenging in the clinic and can cause significant hemodynamic fluctuations [5, 6].

The strong response of DLT tracheal intubation is caused by the direct mechanical stimulation by the laryngoscope on the larynx and trachea and catheter during the intubation process [7]. During intubation,

stress can be reduced by applying topical anesthesia to the airway to align with the concept of precise anesthesia and rapid recovery (enhanced recovery after surgery, ERAS) [8]. The base of the tongue, epiglottis, piriform fossa, and vallecula are all innervated by the SLN[9]. Therefore, SLN block combined with transtracheal topical anesthesia can effectively inhibit the strong stress response in the throat and trachea caused by tracheal intubation. The anesthetic effect of this method has been fully demonstrated during conscious intubation [10]. Ultrasound-guided nerve block and transtracheal injection increase the success rate of nerve block and puncture and improve the reliability of the anesthesia [11, 12].

Flexible intubation scope (FIS) can also be used as it is less traumatic and offers high visibility. Spraying topical anesthetics through the working channel of the FIS using a spray-as-you-go method can gradually complete the airway mucosal surface anesthesia from the throat to the bronchus [13]. As this procedure does not require other equipment or complex anatomical knowledge, it can be effectively used to reduce trauma and is commonly used in operations involving awake intubation and bronchoscopy [14, 15].

The above two airway topical anesthesia methods have been widely used in awake intubation and have demonstrated clinical efficacy yet there is a lack of studies involving DLT intubation is lacking. This study aimed to compare the application effects of two airway topical anesthesia methods in DLT tracheal intubation.

Materials And Methods

This randomized, double-blinded, prospective clinical trial was registered with the Chinese registry of clinical trials at http://www.chictr.org.cn (ChiCTR2100042847; 30/01/2021). This study was approved by the Ethics Committee of the Affiliated Hospital of North Sichuan Medical College and all patients were recruited under written informed consent. Sixty-six patients with American Society of Anesthesiologists (ASA) I-II physical status thoracic surgery who were between 18–65 years old and required DLT tracheal intubation were included in the study. The random number table method was used to randomly assign the patient in control (Group C), ultrasoud (Group U), and flexible intubation scope (Group F) groups with 22 patients in each group. The exclusion criteria for the study were patients with anticipated difficult airway, allergies to topical anesthesia or other anesthetics, trauma or infection at the puncture site, coagulopathy, pregnant women, and individuals with communication difficulties.

All patients were injected with penehyclidine hydrochloride (0.5 mg intramuscular) 30 min before the operation, blood pressure, heart rate, electrocardiography, pulse oximetry, end-tidal carbon dioxide, and bispectral index (BIS) were initiated in the operation theatre. A peripheral venous channel was established. After intravenous injection of midazolam (0.03 mg/kg) and sufentanil (0.1 ug/kg), a radial artery puncture was performed to monitor the direct arterial pressure. Before the start of anesthesia 5 ml/kg of Ringer's lactate was intravenously infused.

Patients in Group C were induced by an intravenous bolus injection of sufentanil (0.3 ug/kg), etomidate (0.3 mg/kg), and rocuronium (0.8 mg/kg). DLT tracheal intubation was performed when the mask was ventilated with pure oxygen for 3 min and the BIS value was < 60. After successful intubation, the same

operator used a FIS to complete the adjustment and positioning of the dual-cavity position. After 5 min, the patient was changed from the supine to the lateral position.

Patients in Group U received bilateral SLN block and transtracheal injection topical anesthesia [16, 17]. A high-frequency (13.6 MHz, 6 cm) linear array probe was used with the hyoid bone as the initial positioning mark. The probe was then moved downwards and outwards. The thyrohyoid periosteum is located between the hyoid bone and the thyroid cartilage. The position of the SLN was determined by rotating the probe to the sagittal position (Fig. 1a). A 22 G puncture needle was used to inject 2 ml of 2% lidocaine using an out-of-plane method (Fig. 1b). The cricothyroid puncture was marked by the thyroid cartilage and the probe was translated downwards. The high-bright line echo between the thyroid cartilage and the cricoid cartilage was the cricothyroid (Fig. 1c). After a successful puncture using the in-plane technique, 3 ml of 2% lidocaine was injected. Venous induction intubation was performed 5 min later and the same method was used for patients in Group C.

The patients in Group F were intravenously injected with the same anesthetics as the patients in group C. Spray-as-you-go technology was used to perform topical anesthesia of the airways after 3 minutes of pure oxygen ventilation with a mask. An assistant placed the dental pads and lifted the lower jaw. The operator used a FIS equipped with an epidural catheter in the working channel (Fig. 2a) to gradually inject 1 ml of 2% lidocaine into the bilateral piriform crypts, epiglottis, and glottis under the direct view of the mouth. The endoscope was slowly positioned in the subglottic trachea to the main bronchus, and slowly advanced in the trachea whilst continuously spraying 2% lidocaine totaling 3 ml (Fig. 2b-d). If the SpO_2 was lower than 90% during epithelial anesthesia, the operation was suspended and the tracheal intubation was performed after the epithelial anesthesia was completed with mask ventilation for 3 min. The tracheal intubation was the same as those used in patients in Group C.

The intubation and positioning were performed by an anesthesiologist who was skilled in the operation and was blinded to the experimental groups. The intubation and positioning must be successful at the first attempt otherwise the patient was withdrawn from the study. During the entire anesthesia process, an independent person who was blinded to the experimental protocol and grouping was responsible for observing and recording the experimental data. The data included blood pressure and heart rate before anesthesia (T0), before intubation (T1), and at 1 (T2), 3 (T3) and 5 min (T4) after intubation, and immediately after the position change (T5). The occurrence of adverse events, patients with hoarseness, sore throats, and the level of satisfaction with anesthesia were followed for 24 h after surgery.

During the observations, if hypertension (blood pressure > 30% of the base value or SBP > 160 mmHg) or hypotension (blood pressure < 30% of the base value or SBP < 90 mmHg), Nicardipine (0.2 mg) or Phenylephrine (50 ug) was given by intravenous injection. If tachycardia (HR > 100 beats/min) or bradycardia (HR < 50 beats/min) occurred, Esmolol (20 mg) or Atropine (0.5 mg) was given intravenously and repeated administration if necessary.

Statistical analysis

The sample size was calculated according to the preliminary experimental data and based on the fact that the blood pressure 1 min after intubation was significantly higher compared to before anesthesia. A 20% reduction in blood pressure was considered effective. The test level was a = 0.05 and the test efficiency was (1-b) = 0.8. The distribution ratio of the three patient groups was 1:1:1. PASS 15.0 software was used to calculate the sample content for 17 cases in each group. Considering that 20% of the patients were withdrawn, 22 cases were included in each group, with a total sample size of 66 cases.

The data were analyzed using SPSS 23.0 statistical software. The continuous variables are expressed as the mean ± standard deviation and the categorical variables are expressed as proportions (%). The Shapiro-Wilk test was used to test the distribution of the data. Normally distributed data were analyzed using an analysis of variance. Repeated measures data were analyzed using a repeated-measures analysis of variance. The categorical data were analyzed using a Chi-square test or Fisher's exact test. *P*-values of < 0.05 were considered statistically significant.

Results

A total of 66 patients were included in this study. In Group C, 3 patients were withdrawn from the study because of failure to intubate or positioning at the first attempt along with 1 patient in Group U and 1 patient in Group F. Finally, 61 patients were included in the statistical analysis. No significant differences were detected between the three groups of patients in age, gender, weight, height, body mass index, ASA status, intubation position, and catheterization time. Also, no significant differences in baseline vital signs were detected across all of the patients at admission (Table 1).

Table 1
Baseline characteristics of the study participants

Basic information	Group C (n = 19)	Group U (n = 21)	Group F (n = 21)
Age (year)	54.89 ± 7.48	49.38 ± 11.56	52.24 ± 11.67
Male/female	11/8	12/9	13/8
Height (cm)	160.26 ± 6.00	163.57 ± 6.51	164.43 ± 8.54
Weight (kg)	60.89 ± 9.76	58.90 ± 9.58	62.24 ± 10.13
BMI	23.65 ± 3.15	21.95 ± 2.77	22.95 ± 2.77
ASA classification (□/□)	4/15	6/15	3/18
Intubation site (left/right)	13/6	14/7	13/8
With tube time (min)	168.63 ± 56.92	197.14 ± 74.31	176.05 ± 50.08

The blood pressures of patients in the three groups were significantly lower before intubation compared to before anesthesia (P < 0.05). The blood pressure of patients in Group C increased significantly after tracheal intubation (P < 0.05) whilst the blood pressures of patients in Groups U and F remained stable

(Table 2, Fig. 3). Compared to before anesthesia, the heart rates of patients in Group C increased significantly at 1 and 3 min after tracheal intubation ($P < 0.05$) whilst the heart rates of patients in Groups U and F did not significantly fluctuate (Table 3, Fig. 4). The operation times of the topical anesthesia in patients in Group U were 116.8 ± 10.1 s longer compared to Group F at 93.0 ± 10.0s ($P < 0.05$). The incidence of hypertension in patients in Group C was significantly higher in 10 cases (52.6%) compared to patients in Group F (4.8%) ($P < 0.05$) and Group U in which 6 cases (28.6%) were observed. There were 9 cases of tachycardia in Group C, 9 cases in Group U, 4 cases in Group F. In Group U, 4 patients had throat bleeding when the glottis was exposed by the laryngoscope, and 8 patients had poor memory related to the operation during the postoperative follow-up. The patients in Group F did not have hypoxemia during the operation and had no bad memories after the operation (Table 4). No significant differences were observed in postoperative hoarseness, the incidence of sore throats, and satisfaction with anesthesia between the three groups (Table 5).

Table 2
Summary of the changes in mean arterial pressure (MAP).

	Point in time	Group C(n = 19)	Group U(n = 21)	Group F (n = 21)
MAP (mmHg)	T0	96.21 ± 11.26	94.57 ± 11.58	94.62 ± 11.04
	T1	74.74 ± 11.92*	75.81 ± 10.69*	79.67 ± 7.97*
	T2	112.47 ± 13.48*	94.81 ± 18.02	88.33 ± 9.65
	T3	94.89 ± 12.73	84.48 ± 13.45*	79.76 ± 7.09*
	T4	88.84 ± 12.65*	84.14 ± 13.26*	79.57 ± 7.84*
	T5	98.32 ± 12.33	95.00 ± 13.52	90.29 ± 10.22

*$P < 0.05$ Compared to the base value.

Table 3
Summary of the changes in HR.

	Point in time	Group C (n = 19)	Group U (n = 21)	Group F (n = 21)
HR (bpm)	T0	83.63 ± 9.87	83.19 ± 11.12	79.67 ± 9.60
	T1	80.16 ± 11.91	75.76 ± 10.29*	76.81 ± 12.15
	T2	99.21 ± 9.55*	89.14 ± 16.26	85.81 ± 19.20
	T3	90.32 ± 10.90*	82.19 ± 13.46	79.71 ± 13.55
	T4	84.21 ± 9.25	79.05 ± 12.40	78.95 ± 13.12
	T5	88.37 ± 21.40	83.19 ± 19.33	79.71 ± 14.46
*P < 0.05 Compared to the base value.				

Table 4
Summary of the occurrence of adverse events.

Adverse events	Group C (n = 19)	Group U (n = 21)	Group F (n = 21)
High blood pressure	10	6	1†
Tachycardia	9	9	4
Low blood pressure	0	3	0
Bradycardia	0	0	0
Throat bleeding	0	4	0
†P < 0.05 Compared to group C.			

Table 5
Summary of postoperative follow-up.

	Group C (n = 19)	Group U (n = 21)	Group F (n = 21)
Hoarse (mild/medium/heavy)	6/3/0	7/3/0	8/3/0
Sore throat (mild/medium/severe)	0/2/0	0/1/0	2/0/0
Patient satisfaction score	94.47 ± 3.42	95.19 ± 3.78	96.76 ± 2.72

Discussion

In this study, we found that both ultrasound-guided SLN block combined with transtracheal injection and spray-as-you-go airway topical anesthesia can effectively attenuate cardiovascular responses to DLT tracheal intubation and stabilize hemodynamics. Compared to the FIS group, there was no advantage in ultrasound group. Due to the need for ultrasound equipment and there is a risk of bleeding risks and corresponding contraindications for the invasive operation.

The SLN block can effectively inhibit the sensory nerves of the throat and tongue mucosa. This block effectively reduces the adverse irritation caused by the laryngoscope during intubation and the strong stimulation of the DLT in the throat. The success of SLN block requires accurate anatomical positioning and skilled puncture skills particularly in patients that are obese or have abnormal neck anatomy which increases the difficulty of the block its rate of success. The application of ultrasound in the nerve block improves nerve positioning and guides the injection of puncture needles to effectively improve the success rate of the block.

In this study, the patients experienced abnormal sensations in the base of the tongue and throat after receiving a bilateral SLN block. At the same time, the cough response to transtracheal injection is partially relieved [18]. transtracheal injection is a classic method of intratracheal mucosal anesthesia and is also an effective technique commonly used for conscious intubation [19]. One of the key points of transtracheal injection is accurate positioning. According to previous studies, the success rate of the empirical blind method in locating the cricothyroid membrane is less than 50% and even lower for obese patients. In contrast, the accuracy of ultrasound-assisted positioning can be increased to 100% [20–22]. We used ultrasound positioning to guide the puncture needle to break through the cricothyroid membrane and then draw back air to confirm the success of the puncture. After injecting topical anesthesia, patients often have obvious coughing which is conducive to the spread of liquid in the airway. The SLN block combined with transtracheal injection can improve the anesthetic effect during conscious intubation [17].

This study confirmed that this method can be used to reduce the stress response of DLT tracheal intubation and stabilize the hemodynamic effects in patients during intubation. The blood pressure and heart rate of the patients remained stable 1 min after intubation and during the stimulation process of body position changes.

Fiberoptic bronchoscopy is an important tool for conscious intubation. It is the gold standard for guiding awake tracheal intubation [23, 24] and is an effective method for airway topical anesthesia. Also, bronchoscopy is often used to judge and adjust the position of the intubation in DLT tracheal intubation [25]. As the bronchoscope has a small diameter, is soft and visible, it can gradually complete surface anesthesia of the entire respiratory mucosa under direct vision through the mouth or nose. In the awake state, topical anesthesia of using the spray-as-you-go technique can result in nausea and coughing. This approach usually requires appropriate sedation and analgesia that is gradually completed with the cooperation of the patient and can be lengthy [26].

In this study, the FIS group was subjected to the spray-as-you-go technique after induction of anesthesia. As the patient is under anesthesia, the operator can complete the mucosal anesthesia from the throat to

the bronchus whilst also avoiding the patient's cough and a bad memory. As the patient received pure oxygen ventilation with a mask before and after the operation, the operation time was completed within 2 min and so all patients did not develop hypoxemia during epithelial anesthesia.

In this study, the purpose of spraying the topical anesthetic solution using an epidural catheter in the working channel of the FIS was to ensure that the drug solution was more evenly distributed on the surface of the airway mucosa. Even if the patient does not redistribute the liquid through a cough reaction, effective results can be achieved. This study confirmed that the use of FIS spray-as-you-go airway mucosal anesthesia to control the stimulation response of DLT intubation is effective. The stress response during tracheal intubation and body position changes were effectively controlled and the hemodynamics were stabilized.

Whilst no significant differences were observed in the blood pressure and heart rate at patients at different times during intubation between the two methods, the number of cases of hypertension and tachycardia in the FIS group were lower than those in the ultrasound group. These data may be explained as follows. In the ultrasound group, transtracheal injection was used to inject drugs into the subglottic main trachea. The distribution of topical anesthesia in the carina and bronchi may be affected by the cough response of the patient. Patients in the FIS group were sprayed directly from the mouth to the bronchus under direct vision and the multiple side holes of the epidural catheter allowed the drug to be more evenly distributed across the entire airway mucosa. Also, the DLT tracheal intubation was longer than the conventional tube. The intubation process spanned from the carina to the bronchus and it directly stimulated the entire trachea including the bronchus. The endotracheal anesthesia of transtracheal injection may be insufficient for the epitracheal anesthesia of the entire trachea and bronchi. The method of increasing the sample size and using topical anesthesia to develop colors will help to further validate these hypotheses.

Since the relevant operations were performed by skilled senior anesthesiologists, and the bronchoscopy was performed after anesthesia, the two methods are not time-consuming. The SLN block and transtracheal injection of patients in the ultrasound group in the awake state, especially the cough of the patient during intratracheal injection, is an important reason for poor memory after surgery. Coughing caused by transtracheal injection can lead to the risk of accidental injection of topical anesthetics into large blood vessels, topical anesthetic poisoning, bleeding, and airway damage. Also, severe coughing has the associated risk of reflux and aspiration [9, 27, 28].

In this study, 4 patients in the ultrasound group had bloodstains on the glottis when the glottis was exposed by the laryngoscopy and all of the patients had recovered at follow-up. Since the bronchoscopy was implemented after anesthesia, the operator can skillfully use the FIS to complete the topical anesthesia of the entire airway mucosa in a short time. Before and after the operation, the mask was fully ventilated with pure oxygen and no adverse reactions such as hypoxia, nausea, and coughing were reported during awake fibreoptic intubation [15, 29]. However, during the operation, an assistant is often required to hold the lower jaw, fix a dental pad, and complete the drug injection.

Lidocaine is an effective topical anesthetic that can be used safely at a dose of 9 mg/kg in airway mucosal anesthesia [30]. Studies have shown that intratracheal use of lidocaine topical anesthesia can effectively reduce the stress response of tracheal intubation and reduce the incidence of postoperative throat discomfort in patients [31]. In this study, no symptoms of lidocaine poisoning were observed. There were no significant differences in the incidence of postoperative sore throat, hoarseness, and the satisfaction score of anesthesia between the two groups.

This study had several limitations including the lack of monitoring of blood catecholamine levels. The blood pressure of the two groups of patients, especially the FIS group, was lower than the baseline values during anesthesia induction intubation. This may be due to the use of conventional intravenous anesthesia induction drugs. Effective airway topical anesthesia can maintain circulatory stability during the induction intubation process and reduce the amount of anesthetics. The optimal anesthesia induction medication regimen combined with the topical anesthesia technique in the process of DLT tracheal intubation requires further investigation.

In summary, the use of topical airway anesthesia during DLT tracheal intubation can effectively inhibit adverse cardiovascular reactions and stabilize hemodynamics during intubation. As a common auxiliary device in the process of DLT tracheal intubation, bronchoscopy can be used to adjust and locate the position of the intubation, and can be combined with the spray-as-you-go airway mucosal anesthesia method of the bronchoscopy working channel.

Declarations

Ethics approval and consent to participate

This randomized, double-blinded, prospective clinical trial study was registered with the Chinese registry of clinical trials at http://www.chictr.org.cn (ChiCTR2100042847; May 12, 2021). The Research Ethics Committee of the Affiliated Hospital of North Sichuan Medical College approved the study (approval no. 2020ER201-1). This study adhered to the applicable CONSORT guidelines and was performed from February 2021 to December 2021. The first participant enrolled on February 4, 2021. Informed written consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and materials

Data have been uploaded successfully to the Chinese registry of clinical trials at http://www.chictr.org.cn. The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

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Authors' contributions

Chen Changlin are responsible for the idea and design of the study.

Wen Di performed the SLN block and transtracheal injection. Chen Changlin performed the spray-as-you-go technique and drafted the manuscript.

Wang YiZheng and Li Mao collected and analyzed the data.

Yu Qi randomized and controlled the research quality.

Li Hongqiong analyzed the data and prepared the tables and figures.

All authors read and approved the final manuscript.

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Authors' information (optional)

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Figures

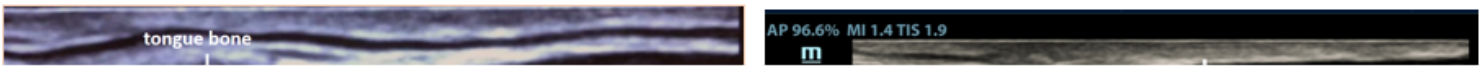

Figure 1

Ultrasound-guided SLN block and transtracheal injection.

Note: (a) The tissue structure around the SLN under sagittal ultrasound, (b) the sagittal out-of-plane puncture under ultrasound. 2 ml of 2% lidocaine solution was injected into the thyroglossal membrane, (c) The location of the cricothyroid membrane under coronal ultrasound.

Figure 2

The technique of spray-as-you-go airway topical anesthesia

Note: (a) A FIS with an epidural catheter was inserted into the working channel. One end of the catheter was connected to a syringe containing 2% lidocaine, (b) the spray on the glottis under the FIS, (c) The anesthetic was sprayed through the side hole of the epidural catheter, (d) Spraying of the carina and bronchi under the FIS.

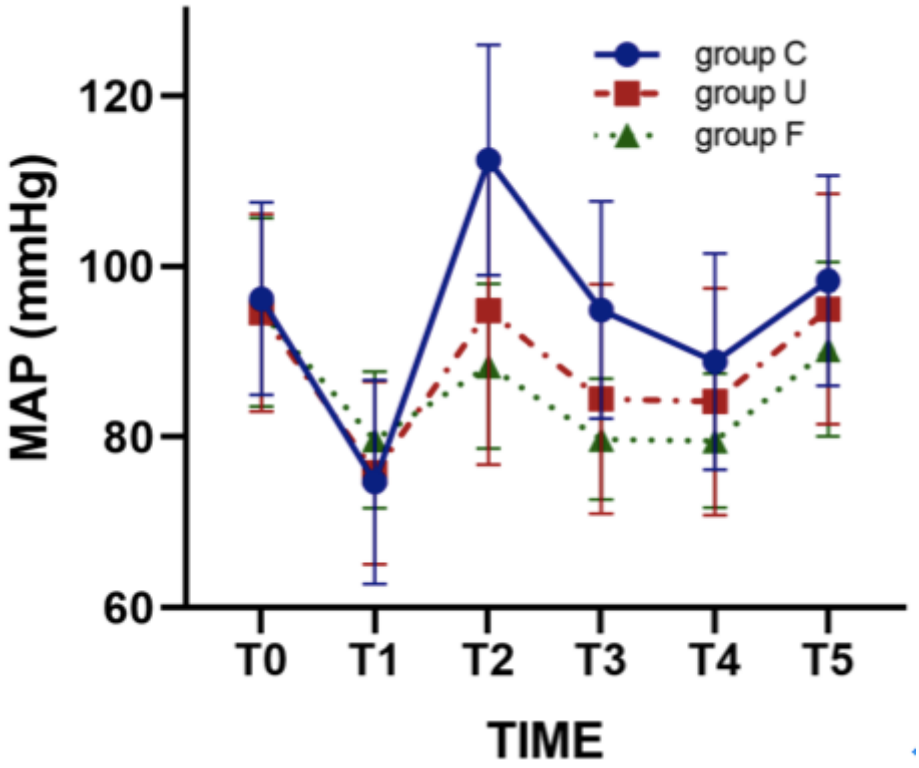

Figure 3

The observed trends in mean arterial pressure (MAP) of the three groups of patients.

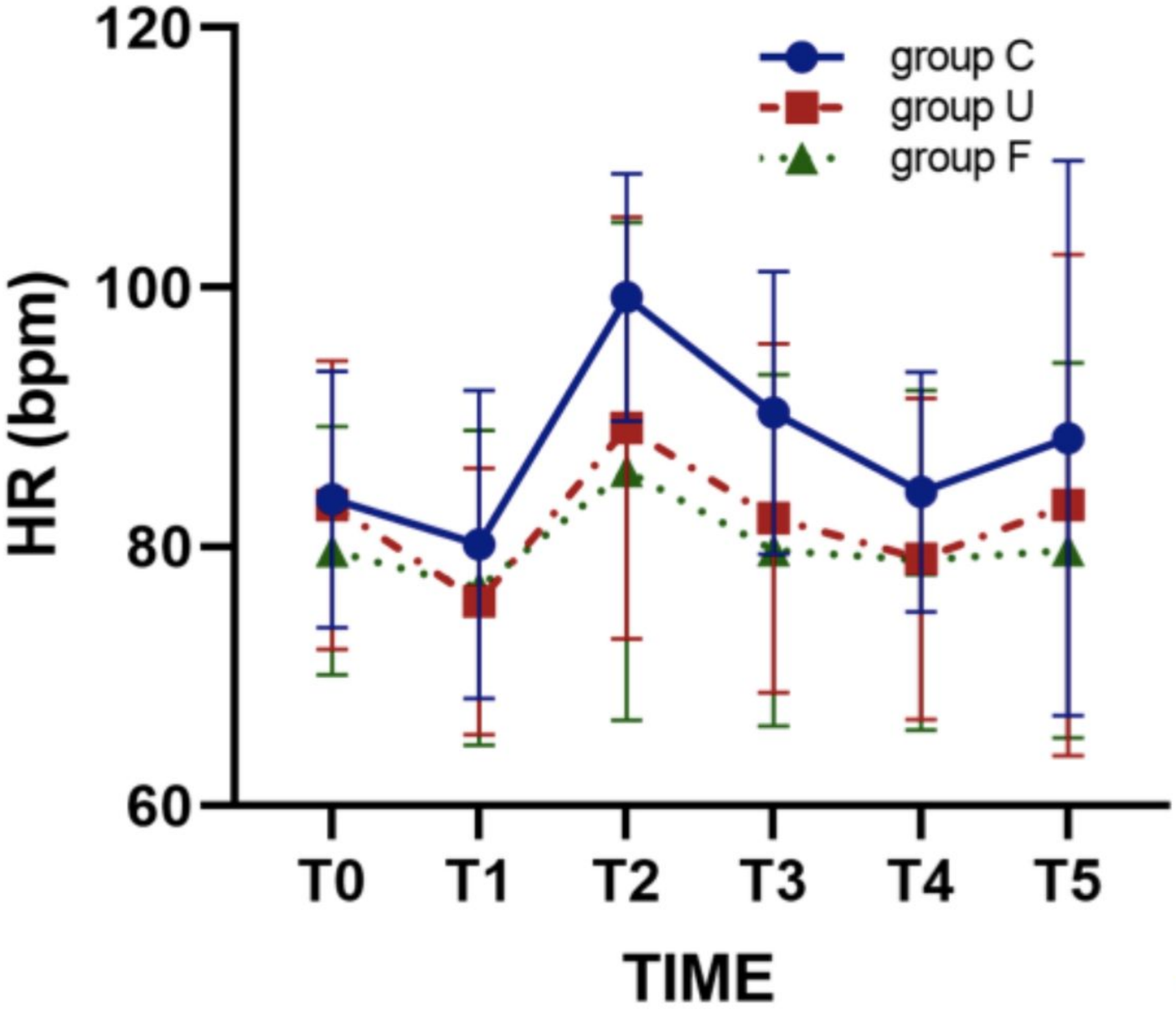

Figure 4

The observed trends in heart rate (HR) of the three groups of patients.