COMPARISON OF 1 MG/L VERSUS 2 MG/L ADRENALINE IN TUMESCENT SOLUTION: HEMODYNAMIC EFFECTS AND CARDIOVASCULAR EVENTS DURING LIPOSUCTION - A RANDOMIZED CONTROLLED TRIAL

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Abstract

Objectives: To compare the hemodynamic changes and cardiovascular adverse events associated with two adrenaline concentrations (1 mg/L vs. 2 mg/L) in tumescent solution for patients undergoing liposuction under general anesthesia. ***Methods:*** A randomized clinical trial was conducted at Le Huu Trac National Burn Hospital (Hanoi, Vietnam) from January to August 2025. 132 ASA I - II patients undergoing elective liposuction were randomly assigned to receive tumescent solution containing either 1 mg/L (group 1, n = 66) or 2 mg/L (group 2, n = 66) adrenaline with lidocaine. Primary outcomes were changes in heart rate (HR) and mean arterial pressure (MAP) recorded at baseline, 30, 60, 90 minutes, and procedure end. Secondary outcomes included the incidence of tachycardia, hypertension, and surgeon satisfaction scores. ***Results:*** Baseline characteristics were comparable between groups. Group 2 demonstrated significantly higher HR and MAP at all post-infiltration timepoints compared to group 1 ($p < 0.05$). Tachycardia incidence was markedly higher in group 2 than in group 1 (31.82% vs 10.61%, $p < 0.05$), consistent with a higher rate of hypertension (22.73% vs 6.06%, $p < 0.05$). Despite pronounced hemodynamic differences, surgeon satisfaction scores remained comparable between groups ($p > 0.05$). ***Conclusion:*** Increasing adrenaline concentration from 1 mg/L to 2 mg/L in tumescent solution is associated with a significantly higher risk of cardiovascular instability without improving surgical outcomes. These findings support the use of 1 mg/L adrenaline as the optimal concentration for tumescent anesthesia in liposuction under general anesthesia.

Keywords: Tumescent anesthesia; Liposuction; Adrenaline; Hemodynamics.

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INTRODUCTION

Liposuction is one of the most widely performed aesthetic procedures for removing localized, treatment-resistant subcutaneous fat and improving body contour. Among the various anesthesia techniques used for liposuction, tumescent anesthesia has revolutionized the field since its introduction by Klein in 1987 [1]. By infiltrating a large volume of diluted lidocaine combined with adrenaline into the subcutaneous fat, the method provides effective analgesia, induces tissue tumescence, and significantly reduces intraoperative blood loss. The use of tumescent anesthesia allows lidocaine to be administered at doses as high as 35 - 55 mg/kg - substantially exceeding the limits of conventional local anesthesia - primarily due to the vasoconstrictive effect of adrenaline, which slows systemic absorption and lowers peak plasma concentrations [2, 3]. Current high-dose lidocaine recommendations are primarily based on American guidelines and pharmacokinetic studies, while specific national guidance for Vietnamese patients remains insufficient. Given potential ethnic and anthropometric differences, a conservative lidocaine dosing strategy was therefore adopted in the present study to enhance patient safety.

Although adrenaline offers important local benefits, it is a potent α- and β-adrenergic agonist capable of producing clinically significant cardiovascular effects, including tachycardia, hypertension, and dysrhythmias [4]. In clinical practice, adrenaline concentrations ranging from 0.5 - 2 mg/L are commonly used in tumescent solutions; however, the optimal balance between achieving sufficient vasoconstriction and minimizing systemic adrenergic adverse events remains unclear. Higher concentrations. such as 2 mg/L are often assumed to enhance hemostasis, however, supporting evidence is limited, especially in procedures performed under general anesthesia, where systemic absorption of adrenaline may exacerbate cardiovascular instability. Despite the widespread use of tumescent anesthesia, few randomized controlled trials have directly compared the cardiovascular impact of 1 mg/L versus 2 mg/L adrenaline in the tumescent solution during liposuction. Therefore, this randomized controlled trial was conducted: *To compare the hemodynamic changes and cardiovascular adverse events associated with two commonly used adrenaline concentrations (1 mg/L vs. 2 mg/L) in tumescent solution during liposuction under general anesthesia, and to evaluate surgical field quality as assessed by surgeon satisfaction.*

MATERIALS AND METHODS

1. Subjects

A total of 132 patients scheduled for elective liposuction at Le Huu Trac National Burn Hospital (Hanoi, Vietnam) between January and August 2025 were included in the study.

* *Inclusion criteria:* Eligible participants were adults aged ≥ 18 years; classified as

American Society of Anesthesiologists (ASA) physical status I - II; and willing to participate after being fully informed about the anesthesia method, medications, and associated procedures.

* *Exclusion criteria:* Patients who presented with coagulation disorders, anemia, cardiovascular diseases (hypertension or arrhythmias), uncontrolled diabetes mellitus, a known allergy to anesthetic drugs (propofol, fentanyl, lidocaine or adrenaline), or the presence of severe intraoperative complications such as anaphylaxis, respiratory failure, or failed airway management that required a change in anesthesia technique; patients whose anesthesia or surgical plan required alteration for any reason that could affect the study data.

2. Methods

* *Study design:* A randomized clinical trial.

* *Group allocation:* Eligible patients were randomly assigned by sealed-envelope draw into two groups: Group 1 (n = 66), who received tumescent anesthesia containing lidocaine combined with 1 mg/L of adrenaline, and Group 2 (n = 66), who received lidocaine combined with 2 mg/L of adrenaline.

* *Study procedure:* After screening and consent, patients were transferred to the operating room, where intravenous access was established, and 0.9% sodium chloride was infused at a rate of 5 mL/min. Standard monitoring was applied, including non-invasive arterial blood pressure, pulse oximetry, ECG lead II, and end-tidal CO_2.

General anesthesia was induced according to the protocol using slow intravenous fentanyl at 3 µg/kg and propofol at 3 mg/kg. Mask ventilation was provided when spontaneous breathing decreased, and endotracheal intubation was performed once muscle relaxation and jaw opening were adequate. After cuff inflation and confirmation of proper tube placement, mechanical ventilation was set in volume-controlled mode with a tidal volume of 5 - 6 mL/kg and a respiratory rate of 12 - 14 breaths per minute, adjusted to maintain end-tidal CO_2 between 35 and 40 mmHg. Anesthesia maintenance was achieved by continuous propofol infusion at 10 - 15 mg/kg/h, titrated in accordance with hemodynamic changes. Additional doses of 30mg propofol and 1 µg/kg fentanyl were provided intravenously whenever the MAP or HR increased by more than 30% from baseline values.

The tumescent solution was prepared using lidocaine 500mg and adrenaline (either 1 mg or 2 mg) in 10mL of 8.4% sodium bicarbonate, diluted in 1000mL of 0.9% normal saline. The infiltration was performed using the super-wet technique, maintaining an approximate 1:1 ratio between the infiltrated volume and aspirated fat. Liposuction was carried out using VASER Lipo ultrasound-assisted technology, which liquefies fat using ultrasound energy before aspiration by negative pressure.

The infiltrated anesthetic volume for each patient was calculated using the Quito formula [5]:

Infiltration volume = Body weight (kg) × Percent body surface area for liposuction × 2.4 (mL)

The maximum allowable lidocaine dose was 35 mg/kg, and the aspirated fat volume was limited to no more than 4000mL. The procedural steps for tumescent infiltration and liposuction followed the standard sequence as illustrated in figure 1.

* *Data collection:* Collected data included demographic characteristics of the patients; total volume of tumescent solution used; the amount of fat aspirated; and changes in HR and MAP at baseline (T0), and at 30 minutes (T30), 60 minutes (T60), 90 minutes (T90), and the end of the procedure. Cardiovascular events such as tachycardia and hypertension defined as an increase exceeding 30% above baseline were documented. Surgeon satisfaction was assessed immediately postoperatively using a five-point Likert scale consisting of "very dissatisfied", "dissatisfied", "neutral", "satisfied," and "highly satisfied" (*Table 1*).

Table 1. Likert scale for surgeons' satisfaction.

Likert level	Definition
Very dissatisfied	Poor surgical field; significant bleeding, markedly impaired visibility; and frequent hemostatic interventions required.
Dissatisfied	Suboptimal surgical field; recurrent bleeding interfering with the procedure; additional hemostatic measures needed.
Neutral	Acceptable but not optimal surgical field; intermittent bleeding causing minor interference; no major interventions required.
Satisfied	Good surgical field; minimal bleeding, smooth fat aspiration; no additional hemostatic measures needed.
Highly satisfied	Excellent surgical field; minimal bleeding, clear visualization, uninterrupted fat aspiration; no need for additional hemostatic interventions.

All collected data were analyzed using SPSS 22.0. Results were presented as means ($\overline{X}$), standard deviations (SD), and percentages (%). Comparisons between categorical variables were made using the Chi-square test, while means of quantitative variables were compared using the Independent Samples T-test. Statistical significance was set at $p < 0.05$.

3. Ethics.

The study complied with the institutional technical guidelines for anesthesia and resuscitation as issued under Decision No. 324/QĐ-BVB on April 1, 2020. Approval for data usage and publication was granted by the Department of Anesthesiology, Le Huu Trac National Burn Hospital. The authors declared to have no conflicts of interest.

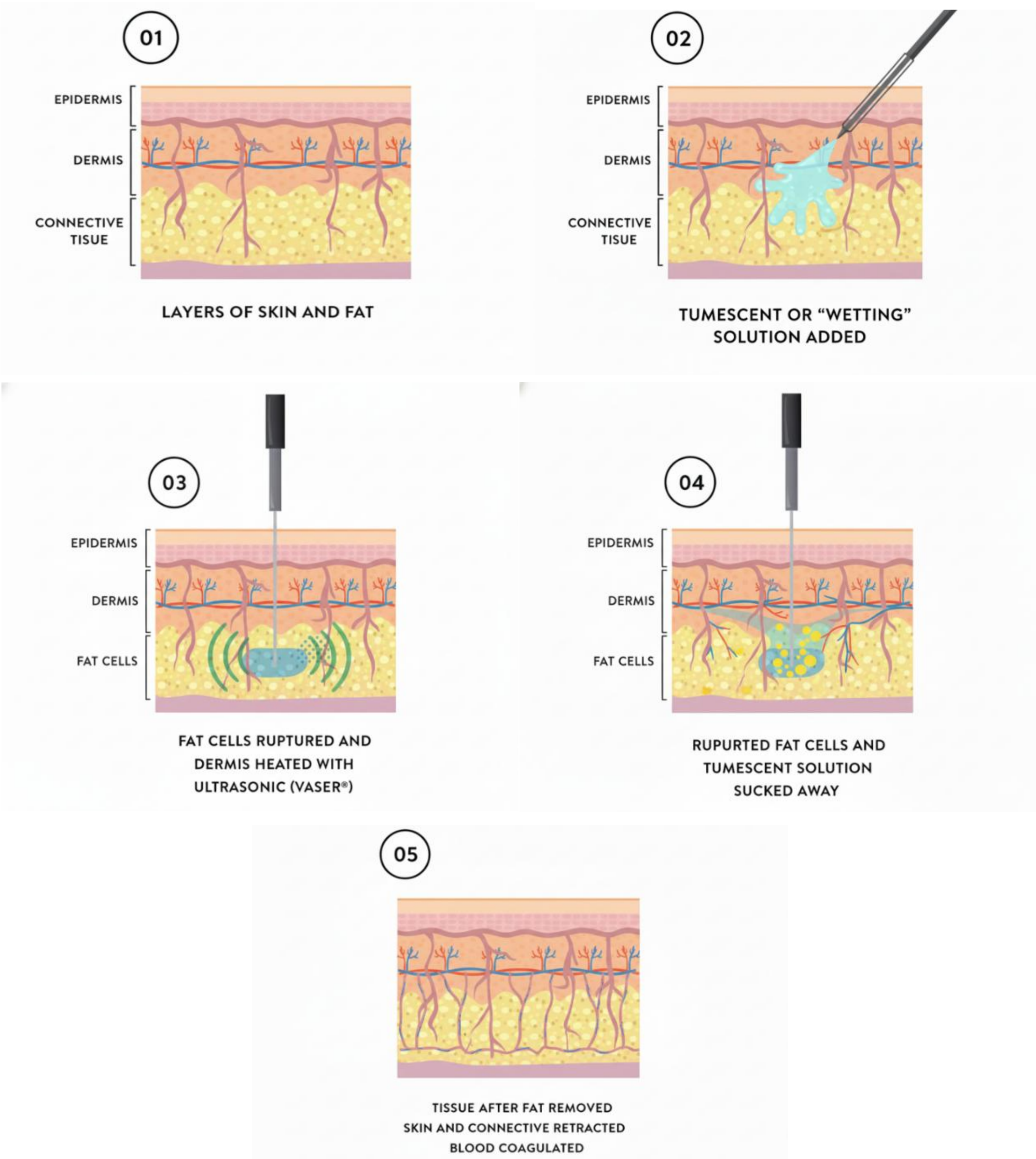

Figure 1. The procedure of tumescent anesthesia and liposuction.

(Source: *https://westcountyplasticsurgeons.wustl.edu/surgery/body-contouring/liposuction.html*)

RESULTS

Table 2. Baseline characteristics of the study population.

Variables	Group 1 (n = 66)	Group 2 (n = 66)	p
Age (years)	37.36 ± 6.70	38.36 ± 6.84	> 0.05
Height (cm)	165.71 ± 7.04	166.58 ± 6.83	> 0.05
Weight (kg)	65.58 ± 4.76	66.71 ± 5.40	> 0.05
BMI	23.91 ± 1.62	24.08 ± 2.04	> 0.05
Liposuction area (%)	17.85 ± 4.68	18.94 ± 4.87	> 0.05
Tumescent volume used (mL)	2791.48 ± 809.26	2980.08 ± 840.74	> 0.05
Lidocaine dose (mg/kg)	20.80 ± 5.05	21.88 ± 5.14	> 0.05

(Data presented as $\overline{X}$ *± SD)*

There were no statistically significant differences between the two groups in terms of demographic characteristics, liposuction area, tumescent volume, or lidocaine dose ($p > 0.05$), indicating that the two groups were comparable at baseline.

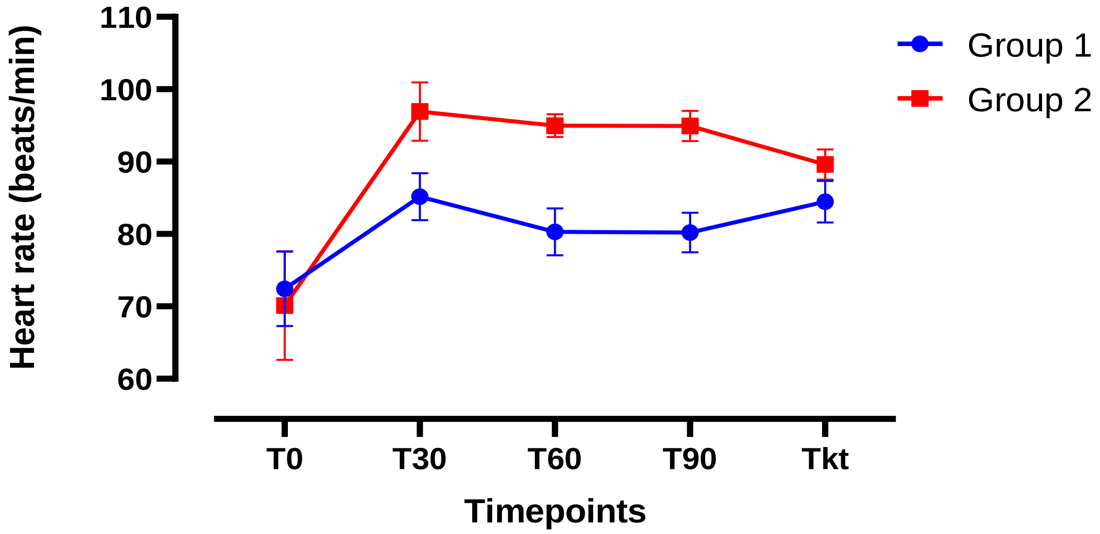

Figure 2. Changes in HR over time during the procedure.

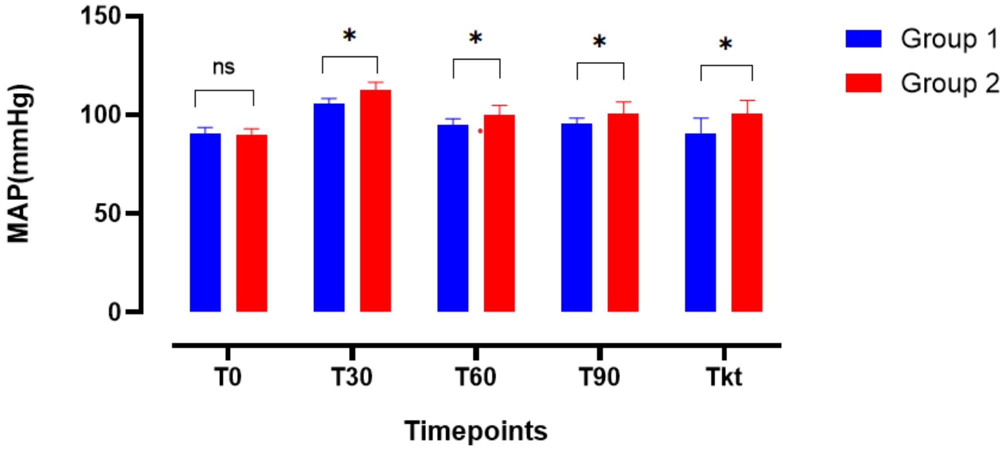

Figure 3. MAP changes over time during the procedure.

*(Data presented as $\overline{X}$ ± SD; *p < 0.05 compared to group 1 at corresponding time points).*

At baseline (T0), HR and MAP were similar between the two groups. However, at 30, 60, and 90 minutes, as well as at the end of the procedure, group 2 (2 mg/L adrenaline) exhibited significantly higher HR and MAP compared with group 1 (1 mg/L) ($p < 0.05$).

Table 3. Incidence of cardiovascular events and surgeons' satisfaction.

Outcome	Group 1 (n = 66)	Group 2 (n = 66)	p
Tachycardia (HR > 30% above baseline)	7 (10.61%)	21 (31.82%)	< 0.05
Hypertension (MAP > 30% above baseline)	4 (6.06%)	15 (22.73%)	< 0.05
Surgeon satisfaction			
Highly satisfied	22 (33.33%)	18 (27.27%)	> 0.05
Satisfied	44 (66.67%)	48 (72.73%)	

Group 2 (receiving 2 mg/L adrenaline) had markedly higher rates of tachycardia and hypertension, representing a nearly three-fold increase compared with the 1 mg/L group ($p < 0.05$). Despite the pronounced hemodynamic instability, surgeon satisfaction was comparable between the two groups ($p > 0.05$), indicating that 1 mg/L adrenaline already provides adequate vasoconstriction and surgical field quality without the additional cardiovascular risks associated with 2 mg/L concentration.

DISCUSSION

This randomized controlled trial evaluated the hemodynamic effects of two adrenaline concentrations (1 mg/L and 2 mg/L) in tumescent anesthesia for liposuction. Despite comparable baseline characteristics between the two groups (*Table 2*), the study demonstrated that increasing the adrenaline concentration from 1 mg/L to 2 mg/L resulted in a clear and clinically significant increase in cardiovascular stimulation during the intraoperative period. Specifically, Group 2 exhibited markedly higher rates of tachycardia and hypertension, representing a roughly three-fold increase compared to Group 1. This pronounced hemodynamic instability contrasts sharply with the surgical outcomes; surgeon satisfaction remained comparable between groups, with 33.33% "highly satisfied" in the 1 mg/L group versus 27.27% in the 2 mg/L group (*Figure 2, 3, and Table 3*). These parallel outcomes reinforce the central conclusion: increasing adrenaline concentration to 2 mg/L significantly magnifies physiological risk without yielding any demonstrable enhancement in surgical quality or hemostatic benefit.

The observed differences in HR and blood pressure between the two groups are consistent with the pharmacological properties of adrenaline. As an α_1- and β_1-adrenergic agonist, adrenaline promotes vasoconstriction while simultaneously increasing myocardial contractility and automaticity. Although low concentrations, such as 1 mg/L, are sufficient to achieve vasoconstriction in subcutaneous tissues, higher doses accelerate systemic absorption, especially during large volume infiltration, thereby amplifying sympathetic stimulation [4, 6]. This pathophysiological mechanism explains why in our study. Group 2 consistently exhibited higher MAP and HR compared to both baseline and Group 1 at every measured time point after infiltration (30, 60, and 90 minutes as well as end of the procedure).

Our findings are strongly corroborated by existing literature. The results are closely consistent with Abosakaya et al., who reported significantly greater increases in HR and MAP at 30 - 60 minutes with 2 mg/L versus 1 mg/L while finding no improvement in surgical field quality or aspirate volume [7]. Furthermore, Prasetyono et al. also found that in hand and upper extremity surgery, a 1mg/L tumescent solution generated a clean surgical field [8]. This concordance strengthens the evidence that raising adrenaline concentration beyond 1 mg/L increases cardiovascular risk without operative benefit. This aligns with Klein's seminal work on tumescent anesthesia, which emphasized using the lowest effective dose because subcutaneous fat permits rapid catecholamine absorption, often more rapidly than lidocaine itself [9]. Our study provides direct clinical confirmation of this principle: increasing the adrenaline concentration beyond 1 mg/L yields no additional hemostatic advantage yet significantly magnifies the likelihood of tachycardia, hypertension, and overall hemodynamic fluctuation. Given that all patients in our study were ASA I - II and free from documented cardiovascular disease, the magnitude of these changes is particularly notable, suggesting that higher-risk patients may be even more vulnerable to adverse effects at higher adrenaline concentrations.

The present study has several limitations that must be acknowledged. Firstly, Plasma concentrations of adrenaline and lidocaine were not measured, which would have provided more direct insight into systemic absorption dynamics. Secondly, the study included only ASA I - II patients and was conducted at a single center, which may limit generalizability. Future research should consider expanding to patients with cardiovascular comorbidities, incorporating pharmacokinetic measurements, and evaluating postoperative outcomes such as pain, recovery time, and delayed cardiovascular events.

CONCLUSION

Based on this randomized controlled trial involving 132 patients undergoing elective liposuction, an adrenaline concentration of 1 mg/L in tumescent solution was found to provide an optimal balance between surgical efficacy and cardiovascular safety. Increasing the concentration to 2 mg/L did not confer additional surgical benefit but was associated with a significantly higher incidence of tachycardia and hypertension. These findings support the preferential use of lower adrenaline concentrations in tumescent anesthesia for liposuction under general anesthesia.

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