Original Research Article

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Effect of controlled hypotensive anesthesia on intraoperative blood loss and surgical field visibility in micro-ear surgery

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Abstract

Background: Micro-ear surgery demands an immaculate surgical field, yet conventional anesthesia often leads to capillary ooze that obscures delicate structures. Controlled hypotensive anesthesia (CHA) is a strategy to mitigate this by reducing mean arterial pressure, but its comparative effectiveness in micro-ear surgery requires further validation.

Objective: To compare the effect of CHA versus normotensive anesthesia on intraoperative blood loss and surgical field visibility in patients undergoing micro-ear surgery.

Methods: A case-control study was conducted at Ibn Sina Medical College and Hospital, Dhaka, Bangladesh, from January 2023 to December 2024. A total of 80 patients were selected via purposive sampling: 40 cases received CHA, and 40 controls received standard normotensive anesthesia. Intraoperative blood loss was measured volumetrically. Surgical field visibility was assessed by the blinded primary surgeon using the 6-point scale at regular intervals. Data were analyzed using the Statistical Package for the Social Sciences version 23.0.

Results: The CHA group ($n = 40$) demonstrated significantly lower mean intraoperative blood loss (47.8 ± 10.5 mL) compared to the control group (101.2 ± 20.3 mL; $P < 0.001$). Surgical field visibility was superior in the CHA group, with 72.5% of cases rated as excellent/good versus 7.5% in controls ($P < 0.001$). No significant difference in surgery duration or major complications was observed between the groups.

Conclusion: CHA significantly reduces blood loss and improves surgical field visibility in micro-ear surgery without increasing operative time or major complications. It is a recommended technique for optimizing surgical conditions in these delicate procedures.

Keywords: Blood loss, controlled hypotension, ear surgery, hypotensive anesthesia, mastoidectomy, tympanoplasty

Introduction

Microsurgery of the ear, encompassing procedures such as tympanoplasty and mastoidectomy, represents a pinnacle of surgical precision, demanding exceptional visualization within a confined and anatomically complex field.[1] Optimal surgical outcomes are inextricably linked to the clarity of the operative field; even minimal bleeding can obscure critical structures, such as the ossicular chain, tympanic membrane remnants, and the facial nerve, potentially prolonging surgery, compromising graft viability, and increasing the risk of iatrogenic injury.[2,3] Consequently, the pursuit of a bloodless field is a paramount concern for otologic surgeons. In conventional anesthetic practice, maintaining normotension is standard. However, this often fails to address the challenge of capillary ooze from the highly vascularized temporal bone mucosa and bone itself. This bleeding is primarily influenced by local capillary pressure, which is directly related to mean arterial pressure (MAP).[4] As a result, surgeons frequently encounter a suboptimal visual field, resorting to repeated suctioning and the use of vasoconstrictors, which can be temporizing and may have systemic implications.[5] To address this persistent challenge, controlled hypotensive anesthesia (CHA) has been advocated as an integral technique in various surgical specialties, including orthognathic, spinal, and endoscopic sinus surgery.[6,7] The principle involves the deliberate, pharmacological reduction of a patient's MAP to a predetermined target range, typically 20–30% below baseline or an absolute MAP of 50–65 mmHg, during the critical phases of surgery, thereby decreasing capillary hydrostatic pressure and surgical bleeding.[8] The intended benefit in otology is a drier operative field, theoretically enhancing surgical precision and efficiency. Recent studies within the last quinquennium have provided renewed evidence supporting the utility of CHA. A 2020 systematic review highlighted its efficacy in reducing blood loss across multiple surgical disciplines, though it called for more procedure-specific data.[9] Specifically in otology, emerging research continues to explore this paradigm. A 2021 prospective study demonstrated significantly improved surgical field scores in functional endoscopic sinus surgery using CHA, a finding relevant to similarly mucosal, confined surgical sites.[10] Furthermore, a 2022 randomized controlled trial focusing on tympanoplasty reported a nearly 50% reduction in measured blood loss and superior surgeon-rated visibility with deliberate hypotension.[3,4] Despite this growing body of international literature, the adoption and standardized evaluation of CHA in micro-ear surgery within specific institutional contexts, such as in Bangladesh, remain less documented. Local factors, including patient demographics, prevalent pathology, and anesthetic protocols, may influence outcomes and safety profiles. While the benefits for surgical visibility are compelling, the technique necessitates careful physiological consideration, particularly regarding end-organ perfusion, underscoring the need for meticulous patient selection and vigilant intraoperative monitoring.[11-14] Therefore, while CHA is theoretically beneficial and supported by contemporaneous international studies, there is a need for localized, robust clinical data to inform evidence-based practice in our setting. This study aims to contribute to this knowledge gap by evaluating the specific effect of CHA on intraoperative blood loss and surgical field visibility in patients undergoing micro-ear surgery at a tertiary care center in Dhaka, Bangladesh. The hypothesis is that the application of CHA will result in a statistically significant reduction in blood loss and a clinically meaningful improvement in the quality of the surgical field compared to standard normotensive anesthesia.

Methodology

This case–control study was conducted in the Department of Anesthesiology at Ibn Sina Medical College and Hospital, Dhaka, Bangladesh, between January 2023 and December 2024. The study population comprised 80 patients undergoing elective micro-ear surgery (tympanoplasty or cortical mastoidectomy), divided into a case group ($n = 40$) receiving CHA and a control group ($n = 40$) receiving normotensive anesthesia. A purposive sampling technique was employed.

Inclusion and exclusion criteria

Patients aged 18–60 years with an American Society of Anesthesiologists (ASA) physical status of I or II were included. Exclusion criteria comprised significant cardiovascular, renal, or hepatic disease, uncontrolled hypertension, cerebrovascular disease, severe anemia (hemoglobin <10 g/dL), coagulopathy, and use of medications affecting hemodynamic stability.

Study procedure

In the case group, controlled hypotension was induced post-intubation to maintain a MAP of 55–65 mmHg using a titrated infusion of nitroglycerine. The control group maintained a MAP within 20% of the pre-induction baseline. For all patients, intraoperative blood loss was calculated quantitatively by measuring suction canister fluid and weighing surgical gauze. The primary surgeon, blinded to the patient's group and MAP, assessed the surgical field visibility every 30 min using the validated from 6-point scoring scale (1 = excellent, 6 = massive bleeding).

Data collection and analysis

Demographic, hemodynamic, and surgical data were recorded on a structured case record form. Data analysis was performed using IBM Statistical Package for the Social Sciences Statistics version 23.0. Continuous variables were expressed as mean ± standard deviation and compared using independent sample t-tests. The ordinal from scale data were analyzed using the Mann–Whitney U test. Categorical data were presented as frequencies and percentages, compared using the Chi-square or Fisher's exact test. $P < 0.05$ was considered statistically significant.

Results

A total of 80 patients completed the study: 40 cases receiving CHA and 40 controls. The baseline demographic and clinical characteristics of the two groups were comparable, with no statistically significant differences in age, gender distribution, ASA physical status, or type of surgical procedure performed (all $P > 0.05$) [Table 1].

The targeted hemodynamic intervention was successfully achieved. The mean intraoperative MAP in the CHA group was 60.2 ± 3.8 mmHg, which was significantly lower than the 84.1 ± 4.9 mmHg recorded in the control group ($P < 0.001$). The mean heart rate was also significantly lower in the CHA group [Table 2].

The primary outcome, intraoperative blood loss, was markedly reduced in the CHA group. The mean blood loss was 47.8 ± 10.5 mL in the case group, compared to 101.2 ± 20.3 mL in the control group, representing a 52.8% reduction ($P < 0.001$) [Table 3].

Surgical field visibility, as rated by the blinded surgeon using the from scale, was significantly superior in the CHA cohort. Assessments in the CHA group were predominantly (72.5%) rated as "Excellent" or "Good" (from scores 1 to 2) [Table 4].

Table 1: Baseline demographic and clinical characteristics

Characteristic	CHA group (*n*=40) (%)	Control group (*n*=40) (%)	*P*-value
Age (years), mean±SD	35.1±9.8	36.4±10.2	0.561
Male gender, *n* (%)	24 (60.0)	22 (55.0)	0.648
ASA I, *n* (%)	33 (82.5)	31 (77.5)	0.782
Tympanoplasty, *n* (%)	25 (62.5)	23 (57.5)	0.651
Mastoidectomy, *n* (%)	15 (37.5)	17 (42.5)	0.651

Data analyzed using an independent t-test (age) and a Chi-square test (categorical variables). ASA: American Society of Anesthesiologists, CHA: Controlled hypotensive anesthesia

Table 2: Intraoperative hemodynamic parameters

Parameter	CHA group (*n*=40)	Control group (*n*=40)	*P*-value
Mean arterial pressure (mmHg)	60.2±3.8	84.1±4.9	<0.001
Heart rate (beats/min)	67.8±6.5	75.4±7.9	<0.001

Data analyzed using an independent t-test. CHA: Controlled hypotensive anesthesia

Table 3: Primary and secondary surgical outcomes

Outcome measure	CHA group (*n*=40)	Control group (*n*=40)	*P*-value
	Mean±SD		
Blood loss (mL)	47.8±10.5	101.2±20.3	<0.001
Surgery duration (min)	115.3±22.7	120.8±26.1	0.312
Irrigation fluid (mL)	130.5±28.4	215.8±50.6	<0.001

Data analyzed using an independent t-test. SD: Standard deviation, CHA: Controlled hypotensive anesthesia

Table 4: Distribution of surgical field visibility (from scale)

From scale score	Description	CHA group, *n* (%)	Control group, *n* (%)
1	Excellent (No bleeding)	10 (25.0)	0 (0.0)
2	Good (Minimal)	19 (47.5)	3 (7.5)
3	Adequate (Slight)	9 (22.5)	10 (25.0)
4	Moderate (Bleeding)	2 (5.0)	15 (37.5)
5	Severe (Bleeding)	0 (0.0)	9 (22.5)
6	Massive (Bleeding)	0 (0.0)	3 (7.5)

Overall distribution compared using the Mann-Whitney U test, $P<0.001$. CHA: Controlled hypotensive anesthesia

In contrast, only 7.5% of assessments in the control group achieved these top ratings, with the majority (67.5%) falling into the "Poor" category (from scores 4 to 6). The duration of surgery was statistically similar between the groups. However, the volume of irrigation fluid used was significantly lower in the CHA group. Regarding safety, no major adverse events (e.g., organ hypoperfusion or cardiac ischemia) were recorded [Table 5].

The incidence of transient, correctable hypotension was 15.0% in the CHA group and 0% in controls, a non-significant difference ($P = 0.053$). Conversely, intraoperative hypertension occurred in 2.5% of CHA cases versus 12.5% of controls [Table 6].

Discussion

The findings of this case–control study demonstrate that the application of CHA during micro-ear surgery significantly reduces intraoperative blood loss and markedly improves surgical field visibility compared to standard normotensive anesthesia. This aligns with the core physiological principle that reducing MAP lowers capillary hydrostatic pressure, thereby attenuating surgical bleeding.[8] The magnitude of benefit observed, a reduction in blood loss exceeding 50%, is consistent with the established efficacy of this technique across various surgical disciplines requiring a clear operative field.[9] The superior quality of the surgical field, quantitatively demonstrated through the validated

Table 5: Categorized surgical field quality

Field quality category	From score	CHA group (*n*=40)	Control group (*n*=40)	*P*-value
		n (%)		
Excellent/Good	1–2	29 (72.5)	3 (7.5)	<0.001
Adequate	3	9 (22.5)	10 (25.0)	0.796
Poor	4–6	2 (5.0)	27 (67.5)	<0.001

Data analyzed using the Chi-square test. CHA: Controlled hypotensive anesthesia

Table 6: Intraoperative adverse events

Adverse event	CHA group (*n*=40)	Control group (*n*=40)	*P*-value
	n (%)		
Transient hypotension*	6 (15.0)	0 (0.0)	0.053
Bradycardia (<50 bpm)	1 (2.5)	0 (0.0)	1.000
Hypertension**	1 (2.5)	5 (12.5)	0.198

*MAP <55 mmHg for >2 min, responsive to intervention. *Sustained MAP >20% above baseline. Data analyzed using Fisher's exact test. MAP: Mean arterial pressure, CHA: Controlled hypotensive anesthesia

From scale, is the most critical clinical outcome. A clear field is indispensable in micro-ear surgery for the safe identification and manipulation of delicate structures such as the ossicular chain and the facial nerve.[2] The stark contrast in visibility ratings, where the majority of CHA cases were rated optimal versus the majority of controls rated suboptimal, provides robust evidence supporting CHA's role in facilitating surgical precision. This finding is corroborated by recent otology-specific research confirming improved surgeon-rated conditions with deliberate hypotension.[4] The concomitant significant reduction in irrigation fluid use in the CHA group further objectively supports the subjective assessment of a drier field.[15] Importantly, these significant advantages were achieved without increasing the duration of surgery. This indicates that the time invested in achieving and maintaining controlled hypotension is offset by the efficiency gained from operating in a clearer field, a net balance previously noted in similar contexts.[6] Regarding safety, the protocol used in this study, involving strict hemodynamic targets in carefully selected patients, proved to be well-tolerated. The absence of major adverse events reinforces the conclusion from recent analyses that CHA can be safely implemented in otologic surgery with appropriate monitoring.[11,16] The transient hypotensive episodes in the CHA group were readily managed, whereas the occurrence of hypertension in some control patients highlights that normotension itself can be challenging to maintain under surgical stress. This study has certain limitations. Its case–control design, while pragmatic, carries inherent risks of selection and confounding bias compared to a randomized trial. The use of purposive sampling and a single-center setting may affect the generalizability of the findings. Furthermore, the assessment of the surgical field, though performed by a blinded surgeon, remains subjective. Future randomized controlled trials with larger, multicentric cohorts and perhaps objective measures of field clarity (e.g., through image analysis) would strengthen the evidence base.[17] This study provides compelling evidence that CHA is a highly effective and safe technique for optimizing surgical conditions in micro-ear procedures. By significantly reducing blood loss and improving field visibility without prolonging surgery or compromising patient safety, CHA should be considered a valuable component of the anesthetic and surgical strategy for tympanoplasty and mastoidectomy. Its adoption can enhance surgical precision and potentially contribute to improved patient outcomes.

Limitations

The study limitations include its non-randomized case–control design, which may introduce selection bias. The purposive sampling from a single center limits generalizability. Furthermore, the primary assessment of surgical field quality, though conducted by a blinded surgeon, remains a subjective measure, lacking objective quantification.

Conclusion

This study concludes that CHA is an effective and safe technique for micro-ear surgery. It significantly reduces intraoperative blood loss and provides a superior surgical field visibility compared to normotensive anesthesia, without increasing operative time or major complications. Therefore, its adoption is recommended to optimize surgical conditions and enhance precision during delicate tympanoplasty and mastoidectomy procedures.

Recommendation

CHA should be adopted for micro-ear surgeries to optimize the surgical field. Future multi-center randomized trials with objective field assessment are recommended to strengthen the evidence. Anesthesiologists and surgeons should receive training in this technique.

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