

A Pilot Prospective Study Comparing Monopolar cautery, Bipolar, and Colorado Needle Electrocautery in Brachiocephalic Arteriovenous Fistula Creation

Chetan Prajapati¹, M. F. Shaikh², Pranit D. Mankare³, Shivani Vadodariya⁴, Ronak I. Kadia⁵

¹Associate Professor, General Surgery, Dr M K Shah Medical College and Research Centre, Ahmedabad, Gujarat, India

²Associate Professor, Department of Surgery, Ananya College of Medicine and Research, Kalol. District Gandhinagar, Gujarat, India

³Assistant Professor, Department of General Surgery, ACPM Medical College, Dhule, Gujarat, India

⁴Senior Resident, Burns & Plastic Surgery, B.J. Medical College, Ahmedabad, Gujarat, India

⁵Assistant Professor, Department of Plastic Surgery, B.J. Medical College, Ahmedabad, Gujarat, India

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Corresponding author: Dr. Chetan Prajapati

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Abstract

Background: Arteriovenous (AV) fistula remains the preferred vascular access for maintenance hemodialysis. Surgical technique, particularly the method of electrocautery used for dissection and haemostasis, may influence endothelial integrity, tissue trauma, and fistula outcomes. Comparative evidence regarding different electrosurgical modalities in AV fistula creation is limited.

Methods: This prospective pilot observational study included 25 patients undergoing primary brachiocephalic AV fistula creation at a tertiary care centre over 12 months. Patients were allocated into three groups based on the electrosurgical modality used: monopolar cautery (n = 8), bipolar cautery (n = 8), and Colorado needle electrocautery (n = 9). Allocation was non-randomized and based on surgeon preference. Intraoperative parameters assessed included operative time, blood loss, ease of dissection, and vessel wall thermal injury. Postoperative outcomes included complications and fistula maturation at 6 weeks. Data were analysed descriptively.

Results: The Colorado needle group demonstrated the shortest operative time (48 ± 12 minutes) and lowest blood loss (24 ± 8 mL), compared to bipolar (56 ± 7 minutes; 32 ± 10 mL) and monopolar cautery (62 ± 8 minutes; 49 ± 6 mL). Thermal injury was minimal with the Colorado needle, low with bipolar cautery, and moderate with monopolar cautery. Dissection precision was rated highest in the Colorado needle group. Postoperative complications were infrequent across all groups, with a slightly higher incidence in the monopolar cautery group. Fistula maturation at 6 weeks was observed in 88.9% of patients in the Colorado needle group, 87.5% in the bipolar group, and 75% in the monopolar cautery group. Given the small sample size and non-randomized design, results should be interpreted cautiously.

Conclusion: The Colorado needle electrocautery demonstrated favourable intraoperative characteristics, including improved precision, reduced thermal injury, and lower blood loss, with a trend toward higher fistula maturation rates. Bipolar cautery remains a reliable alternative with effective haemostasis. These findings are preliminary and require validation through larger, randomized controlled studies.

Keywords: Arteriovenous fistula, Electrocautery, Monopolar cautery, Bipolar, Colorado needle, Haemodialysis.

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Introduction

Chronic kidney disease (CKD) requiring maintenance haemodialysis represents a significant and growing global health burden. Reliable vascular access is essential for effective long-term dialysis and directly influences patient outcomes

and quality of life. Among the available options, the native arteriovenous (AV) fistula remains the preferred modality due to its superior long-term patency, lower infection rates, and reduced complication profile compared with prosthetic

grafts and central venous catheters [1–4]. Within upper-limb vascular access strategies, the brachiocephalic AV fistula is commonly performed when radiocephalic fistula creation is not feasible or has previously failed. The success of AV fistula creation is multifactorial, depending on patient-related variables, vascular anatomy, and, importantly, meticulous surgical technique. Preservation of vascular endothelial integrity, minimization of tissue trauma, and achievement of effective haemostasis are critical technical considerations that directly influence fistula maturation and long-term function [2,3].

Electrosurgical devices are routinely employed during AV fistula creation for tissue dissection and haemostasis. Conventional monopolar cautery is widely available and cost-effective; however, it is associated with greater lateral thermal spread, which may increase the risk of collateral tissue injury [5,6]. Bipolar cautery allows more controlled energy delivery with reduced thermal dispersion, thereby potentially minimizing damage to adjacent vascular structures [5]. The Colorado needle, a fine tungsten needle-tip monopolar electrode, has been proposed to provide enhanced precision with reduced thermal injury, combining the accessibility of monopolar systems with improved control [7].

Despite the widespread use of these electrosurgical modalities, there is a paucity of comparative evidence evaluating their impact specifically in vascular access surgery. In particular, data comparing their effects on intraoperative handling, vessel integrity, and early fistula outcomes remain limited.

Therefore, this pilot prospective study was conducted to compare the intraoperative and early postoperative outcomes associated with monopolar cautery, bipolar cautery, and the Colorado needle in brachiocephalic AV fistula creation. The aim was to identify preliminary trends and generate data to inform the design of larger, adequately powered studies. Identifying electrosurgical techniques that minimize endothelial injury may represent a simple and modifiable intraoperative factor to improve fistula success rates.

Materials and Methods

Study Design and Setting: This prospective pilot observational study was conducted at a tertiary care centre over a period of 12 months.

Study Population: A total of 25 patients undergoing primary brachiocephalic arteriovenous (AV) fistula creation for haemodialysis access were included in the study. As a pilot study, no formal sample size calculation was performed; the sample was intended to generate preliminary data. Baseline characteristics appeared comparable across groups;

however, no statistical testing was performed given the pilot nature.

Inclusion Criteria

1. Age between 18 and 75 years
2. End-stage renal disease requiring maintenance haemodialysis
3. Suitable cephalic vein and brachial artery on clinical and Doppler assessment
4. Patients undergoing primary AV fistula creation

Exclusion Criteria

1. Previous ipsilateral AV fistula surgery
2. Presence of central venous stenosis
3. Coagulopathy
4. Active infection
5. Severe peripheral arterial disease

Group Allocation

Patients were categorized into three groups based on the electrosurgical modality used during the procedure:

Group A: Monopolar cautery (n = 8)

Group B: Bipolar cautery (n = 8)

Group C: Colorado needle electrocautery (n = 9)

Patients were allocated to the study groups based on surgeon preference and availability of electrosurgical equipment. No randomization or allocation concealment was performed. This pragmatic approach reflects real-world surgical practice but introduces potential selection bias. Blinding was not performed due to the nature of the intervention.

Surgical Technique: All procedures were performed by single surgeon under regional or local anaesthesia, depending on patient suitability. A standard transverse incision was made at the antecubital fossa. The cephalic vein and brachial artery were identified, dissected, and mobilized with careful preservation of surrounding structures.

Following adequate vessel preparation, an end-to-side arteriovenous anastomosis was performed using polypropylene sutures with magnification.

The assigned electrosurgical modality (monopolar cautery, bipolar cautery, or Colorado needle) was used for tissue dissection and haemostasis throughout the procedure. Care was taken in all cases to minimize thermal injury and preserve vascular integrity.

Outcome Measures

Intraoperative Outcomes

- **Operative time (minutes):** Time from skin incision to completion of wound closure

- **Estimated blood loss (mL):** Calculated using surgical swab assessment by gravimetric analysis
- **Ease of dissection:** Subjectively graded by the operating surgeon (easy/moderate/difficult)
- **Vessel wall thermal injury:** Assessed intraoperative based on visual evidence of charring or adjacent tissue damage.

These assessments were operator-dependent and may introduce observer bias. Thermal injury and dissection ease were subjectively assessed by the operating surgeon without validated scoring systems, representing a potential source of observer bias.

Postoperative Outcomes

- Patients were followed for early postoperative outcomes, including:
- Hematoma formation
- Wound infection
- Limb edema
- Presence of thrill (assessed clinically immediately postoperatively and during follow-up)
- Primary fistula maturation at 6 weeks, defined as a clinically usable fistula with adequate flow for haemodialysis. (Only early maturation assessed; long-term patency not evaluated)

Statistical Analysis: Data were analysed using descriptive statistical methods appropriate for a pilot study. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages.

Given the pilot nature and limited sample size, the study was not powered for inferential statistical analysis; findings are descriptive and hypothesis-generating.

Ethical Considerations: The study was conducted in accordance with institutional ethical standards. Approval was obtained from the institutional ethics committee, and informed consent was obtained from all participants prior to inclusion.

Results

Baseline Characteristics: A total of 25 patients were included in the study and distributed into three groups: monopolar cautery ($n = 8$), bipolar cautery ($n = 8$), and Colorado needle electrocautery ($n = 9$).

Intraoperative Outcomes

- Descriptive analysis demonstrated variations in intraoperative parameters among the three groups. The Colorado needle group exhibited the shortest mean operative time (48 ± 12

minutes), followed by the bipolar group (56 ± 7 minutes) and the monopolar group (62 ± 8 minutes).

- Estimated intraoperative blood loss was highest in the monopolar group (49 ± 6 mL), intermediate in the bipolar group (32 ± 10 mL), and lowest in the Colorado needle group (24 ± 8 mL).
- Subjective intraoperative assessment indicated moderate vessel wall thermal injury in the monopolar group, low thermal injury in the bipolar group, and minimal thermal injury in the Colorado needle group. Similarly, ease and precision of dissection were graded as moderate with monopolar cautery, good with bipolar cautery, and excellent with the Colorado needle.

Postoperative Complications

- Postoperative complications were infrequent across all groups. In the monopolar group, one patient developed a hematoma and two patients experienced wound edema. In the bipolar group, one patient each developed wound infection and early thrombosis, and one patient had wound edema. In the Colorado needle group, one case of early thrombosis was observed, with no instances of hematoma, wound edema, or infection.
- Overall, the monopolar group demonstrated a slightly higher incidence of minor postoperative complications compared to the other groups.

Fistula Maturation: At 6-week follow-up, fistula maturation was observed in 6 out of 8 patients (75%) in the monopolar group, 7 out of 8 patients (87.5%) in the bipolar group, and 8 out of 9 patients (88.9%) in the Colorado needle group.

Summary of Findings: Descriptive analysis suggests that the Colorado needle electrocautery may be associated with shorter operative time, reduced intraoperative blood loss, minimal thermal injury, and improved precision of dissection. Bipolar cautery demonstrated effective haemostasis with moderate operative times and low thermal injury. In contrast, monopolar cautery was associated with relatively higher blood loss, longer operative time, and greater thermal tissue effects.

Although fistula maturation rates appeared higher in the bipolar and Colorado needle groups, the small sample size limits definitive conclusions, and these findings should be considered hypothesis-generating.

Table 1: Intraoperative outcomes

Parameter	Monopolar	Bipolar	Colorado needle
Operative time (min)	62 ± 8	56 ± 7	48 ± 12
Blood loss(mL)	49 ± 6	32 ± 10	24 ± 8
Vessel wall thermal injury	moderate	Low	Minimal
Ease/precision of dissection	moderate	Good	Excellent

Table 2: (Age, Gender, Diabetes Mellitus, Hypertension, Vessel Diameter)

Variable	Monopolar (n = 8)	Bipolar (n = 8)	Colorado Needle (n = 9)
Age (years, mean ± SD)	51.1 ± 8.3	50.5 ± 9.1	52.8 ± 8.7
Male, n (%)	5 (62.5%)	4 (50%)	5 (55.6%)
Diabetes Mellitus, n (%)	5 (62.5%)	4 (50%)	6 (66.7%)
Hypertension, n (%)	4 (50%)	4 (50%)	5 (55.6%)
Vessel Diameter (mm, mean ± SD)	3.11 ± 0.34	3.06 ± 0.36	3.09 ± 0.39

Table 3: Postoperative complication

Complication	Monopolar(n=8)	Bipolar(n=8)	Colorado needle(n=9)
hematoma	1	0	0
Wound oedema	2	1	0
infection	0	1	0
Early thrombosis	0	1	1

Table 4: Fistula maturation at 6 week.

Group	Matured fistula
Monopolar cautery	6/8(75%)
Bipolar cautery	7/8(87.5%)
Colorado needle	8/9(88.9%)

Discussion

The findings of this pilot study suggest that the choice of electrosurgical modality may influence intraoperative handling and early outcomes in brachiocephalic arteriovenous (AV) fistula creation. In vascular surgery, precise dissection with preservation of endothelial integrity is essential, as even minimal thermal injury may adversely affect vessel patency and subsequent fistula maturation [1–4].

The Colorado needle demonstrated favourable trends, including improved precision, reduced intraoperative blood loss, and minimal observable thermal injury compared with monopolar and bipolar cautery. These findings are consistent with previous reports indicating that fine-tip monopolar devices allow more focused energy delivery with reduced lateral thermal spread [5,7], thereby minimizing collateral tissue damage. Enhanced precision during dissection may facilitate preservation of the vascular endothelium and surrounding structures, which are critical determinants of successful fistula maturation. The observed reduction in blood loss and thermal injury with the Colorado needle may therefore have important mechanistic implications for endothelial preservation, a key factor in vascular access outcomes [1].

Bipolar cautery provided effective haemostatic control with lower thermal dispersion relative to monopolar cautery. This is consistent with the

fundamental principle of bipolar electrosurgery, in which electrical current is confined between the electrodes, thereby limiting unintended tissue injury (6). Previous studies in vascular and microsurgical settings have similarly demonstrated that bipolar cautery achieves reliable haemostasis with reduced lateral thermal spread [5].

In contrast, monopolar cautery, although widely used due to its accessibility and cost-effectiveness, was associated in this study with greater thermal spread and visible tissue charring. Experimental and clinical evidence suggests that monopolar electrocautery can generate higher temperatures and deeper tissue injury, potentially leading to endothelial damage and impaired vascular healing [5,6]. These effects may contribute to the relatively lower fistula maturation rates observed in the monopolar group. Postoperative complications were infrequent across all groups, reflecting the overall safety of AV fistula creation when performed with meticulous surgical technique. A trend toward fewer complications in the Colorado needle group may be attributable to reduced tissue trauma and improved surgical precision. Similar associations between minimized thermal injury and improved wound healing have been described in studies evaluating electrosurgical energy modalities [8].

The findings of this study should be interpreted in light of several limitations. The small sample size and pilot nature limit statistical power and

generalizability. In addition, the non-randomized design, with allocation based on surgeon preference, introduces potential selection bias and confounding, as intraoperative judgment and patient-specific factors may have influenced the choice of electrosurgical modality. Consequently, the observed differences between groups cannot be attributed solely to the intervention, and causal inferences should be made with caution. The absence of randomization and blinding further increases the risk of performance and observer bias, particularly for subjective intraoperative assessments such as ease of dissection and evaluation of thermal injury. Moreover, the short follow-up period precludes assessment of long-term fistula patency and durability.

Despite these limitations, this study provides preliminary insights into the potential impact of electrosurgical modality on AV fistula outcomes and highlights clinically relevant trends that warrant further investigation. The higher cost and limited availability of Colorado needle electrodes may influence their adoption, particularly in resource-constrained settings. Nevertheless, the consistent directional trends observed across intraoperative parameters support the biological plausibility of the findings.

Future studies with larger sample sizes, randomized controlled designs, and objective assessment of thermal injury are required to validate these findings. In addition, evaluation of cost-effectiveness will be important, particularly in settings with limited resources. If confirmed in larger studies, the choice of electrosurgical modality may represent a simple and modifiable intraoperative factor to improve arteriovenous fistula outcomes.

Conclusion

This pilot study suggests that the choice of electrosurgical modality may influence intraoperative performance and early outcomes in brachiocephalic arteriovenous fistula creation. The Colorado needle electrocautery demonstrated favourable trends, including enhanced precision, reduced thermal injury, and higher rates of early fistula maturation.

Bipolar cautery provided effective haemostasis with lower thermal dispersion and represents a reliable alternative, particularly in settings where Colorado needle is not readily available. In contrast, monopolar cautery, although widely accessible, was associated with relatively greater thermal effects and should be used with caution in proximity to vascular structures.

Fistula maturation rates were highest in the Colorado needle group, followed by bipolar and monopolar cautery; however, these observations should be interpreted with caution in view of the limited sample size. Among the evaluated modalities, the Colorado needle demonstrated the most favourable intraoperative profile, suggesting a potential technical advantage in delicate vascular procedures. The cost and learning curve associated with Colorado needle electrocautery may influence its adoption in routine practice.

Given the non-randomized design and small sample size, these findings should be interpreted as preliminary and hypothesis-generating. Further validation through larger, well-designed randomized controlled trials is required to establish definitive clinical recommendations.

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