

Comparative Study of Safety and Efficacy of α -n-Butyl-2-cyanoacrylate Glue versus Traditional Embolization Materials in the Treatment of Acute Renal Hemorrhage

Liping Jiang^{1,*}, Xu Wang¹, Youting Zhang², Qibin Wang¹, Hongmei Zhang¹, Luoyi Ren¹

¹Department of Interventional Diagnosis and Treatment, The First Affiliated Hospital of Shihezi University, Shihezi, Xinjiang, China

²Imaging Center, The First Affiliated Hospital of Shihezi University, Shihezi, Xinjiang, China

*Correspondence: jlj201900972@163.com (Liping Jiang)

Abstract

Aims/Background This study aims to evaluate the safety and efficacy of α -n-butyl-2-cyanoacrylate (NBCA) glue in comparison with traditional embolization materials for the treatment of acute renal hemorrhage.

Methods A total of 105 patients with the acute renal hemorrhage who underwent superselective renal artery embolization were enrolled. The patients were divided into two groups based on the embolization materials used: the traditional group (43 cases, control group) and the medical glue group (62 cases, observation group). Demographic characteristics, medical history, preoperative and postoperative 24-hour blood counts, renal function, and other clinical data were collected. The safety and efficacy of the two treatment methods were then compared between the groups.

Results No significant difference in efficacy was observed between the traditional group and the medical glue group ($p > 0.05$). However, significant differences were found between the two groups in terms of embolization vessel grade, systemic immune-inflammation index (SII) difference, estimated glomerular filtration rate (eGFR) difference, and combined eGFR difference ($p < 0.05$). The traditional group exhibited a higher postoperative inflammatory response and greater renal function damage compared to the medical glue group. The degree of vascular embolization also influenced the extent of postoperative inflammatory response and renal function damage in patients with acute renal hemorrhage.

Conclusion Compared to traditional embolization materials, NBCA glue demonstrates a clear hemostatic effect in the treatment of patients with acute renal hemorrhage, while also leading to reduced postoperative inflammatory response and renal function damage. NBCA adhesive is both safe and effective for treating acute renal hemorrhage.

Key words: acute renal hemorrhage; superselective renal artery embolization; n-butyl-cyanoacrylate; therapeutic effect

Submitted: 9 August 2024 Revised: 17 September 2024 Accepted: 24 September 2024

How to cite this article:

Jiang L, Wang X, Zhang Y, Wang Q, Zhang H, Ren L. Comparative Study of Safety and Efficacy of α -n-Butyl-2-cyanoacrylate Glue versus Traditional Embolization Materials in the Treatment of Acute Renal Hemorrhage. Br J Hosp Med. 2024. <https://doi.org/10.12968/hmed.2024.0514>

Copyright: © 2024 The Author(s).

Introduction

Acute renal hemorrhage is a common surgical emergency, primarily caused by various iatrogenic renal injuries (e.g., renal surgery, renal biopsy, puncture), trauma, tumours, and renal vascular diseases. The main clinical manifestations include low back pain, gross hematuria, or drainage fluid (bright red non-condensable fluid),

and may be accompanied by decreased blood volume and severe hemorrhagic shock (Limtrakul et al, 2020). Treatment options primarily consist of conservative medical management and surgical hemostasis. Although traditional surgical methods offer effective hemostasis, they are often rejected by patients due to their complexity. Additionally, when the bleeding site cannot be clearly identified, it may be necessary to remove the entire affected kidney, resulting in significant physical and psychological trauma for the patient. In 1973, Bookstein and Ernst (1973) first employed superselective renal artery embolization (SRAE) to treat renal hemorrhage. Due to its minimally invasive nature, significant efficacy, and ability to preserve renal function, SRAE has gained widespread acceptance and has become the preferred treatment for acute renal hemorrhage (Güneyli et al, 2015; Muller and Rouvière, 2015).

However, given the diversity of causes of renal hemorrhage, the angiographic findings can vary, and a range of embolization materials with different properties are available. As SRAE becomes increasingly standardized, selecting the appropriate embolization material for precise treatment is critical. The impact of different embolization materials on renal function remains unclear, and there is currently no established diagnosis and treatment standard or expert consensus in clinical practice (Schwartz et al, 2007). Compared to conventional embolization materials such as coils and gelatin sponges, a newer material, medical glue, showed no significant difference in efficacy or postoperative renal function in patients with acute renal hemorrhage (Hill et al, 2018). However, this finding requires further validation.

In this study, we retrospectively analyzed patients with acute renal hemorrhage undergoing interventional surgery to assess the efficacy and safety of different embolization materials in SRAE for renal hemorrhage.

Methods

Clinical Data

The present study was retrospective in design. Patients with acute renal hemorrhage who underwent SRAE at The First Affiliated Hospital of Shihezi University from 2019 to 2023 were recruited. A total of 105 patients were included, consisting of 71 males and 34 females. Based on the embolization materials used, the patients were divided into two groups: the traditional group (43 cases, control group) and the medical glue group (62 cases, observation group).

The inclusion criteria were as follows: patients with hematuria due to various causes, a continued decline in hemoglobin levels, fluctuating or decreasing blood pressure, ineffective conservative treatment, computed tomography (CT) or other imaging examinations revealing renal active bleeding or vascular abnormalities, and patients with complete clinical data. The exclusion criteria were: patients with liver or kidney dysfunction, coagulation disorders, malignant tumours or other significant diseases, renal cysts, renal tuberculosis, or other renal conditions, incomplete clinical data; and patients lost to follow-up.

Surgical Equipment

The instrumentation used in this study included digital subtraction angiography (DSA) (Philips Investment Co., Ltd., Philips Uniq FD20, batch no.: 20143065289, Beijing, China), an x-ray computed high-pressure syringe (Accutron HP 832 Injector, batch no.: 832020256, Medtronic, Inc., Minneapolis, MN, USA), iohexol contrast agent (100 mL: 30 g, Yangtze River Pharmaceutical Group Co., Ltd., Taizhou, China, batch no.: 24032861), a 5F vascular long sheath (Int Medical, batch no.: K202403165), a 5F pig-tail drainage tube (Cordis (Shanghai) Medical Devices Co., Ltd., Shanghai, China, batch no.: 451-503H5), and a 5F Cobra catheter (Cordis (Shanghai) Medical Devices Co., Ltd., Shanghai, China, batch no.: 451-543H0). Additional equipment included a hydrophilic guide wire (0.035 inches, batch no.: 231216V), a 2.7F microcatheter system (Terumo Vietnam Co., Ltd., Tokyo, Japan, batch no.: 230915), gelatin sponge particles (1000–1400 μm , Hangzhou Alicon Pharmaceutical Sci & Tec Co., Ltd., Hangzhou, China, batch no.: 30132408), micro-spring coils (ϕ 3–5 mm, Cook Incorporated, Shanghai, China, batch no.: 15719513), and n-butyl-2-cyanoacrylate (NBCA, 15 mg/mL, 0.5 mL, Beijing Compont Medical Devices Co., Ltd., Beijing, China, batch no.: 240303).

Surgical Procedure

Patients were closely monitored, and the progress of bleeding was evaluated throughout the procedure. Physicians assessed patients who had no contraindications for vascular interventional therapy. After administering local anesthesia (1% lidocaine, 5 mL), femoral angiography was performed in the groin using the Seldinger technique via the femoral artery approach. Vascular access was established through the ipsilateral common femoral artery. A 4Fr angiography microcatheter was inserted into the abdominal aorta at the level of the renal artery, followed by DSA to assess for multiple or accessory renal arteries and any bleeding.

After selectively intubating the renal artery with a 5F angiography catheter over a 0.035-inch hydrophilic guide wire, renal angiography was conducted using a 5 cc non-ionic isotonic contrast agent to evaluate the renal artery condition and lesion location. Based on the DSA results, SRAE was performed by two interventional radiologists with over 10 years of experience. An ultra-fine diagnostic catheter or a 2.8Fr microcatheter was super-selectively inserted into the branch of the damaged renal artery to select the appropriate embolic agent for embolization and hemostasis as close as possible to the responsible lesion artery, minimizing the loss of normal renal parenchyma.

Embolization materials included medical glue, gelatin sponge, micro-spring coils (3–5 mm diameter), or a combination of these materials. Patients were divided into two groups based on the embolization materials used: the medical glue group and the traditional group (micro-spring coil, gelatin sponge, or their combination). If an accessory renal artery was identified, angiography was performed to check for bleeding and embolization for hemostasis.

DSA was repeated after embolization to verify the hemostatic effect and occlusive arterial lesions. Finally, the catheter was removed, and a dressing was applied to the affected groin for 12 hours to prevent hematoma formation. All patients were

carefully monitored postoperatively, and clinical and laboratory tests, along with ultrasound or CT evaluation if necessary, were conducted to assess treatment outcomes, complications, and possible rebleeding risks until stability was achieved.

Data Collection

Demographic characteristics, clinical data, bleeding site, and venous blood samples were collected before the operation and within 24 hours postoperatively. Additionally, hematuria and hemoglobin loss were monitored before the operation and within three days following the procedure. Long-term postoperative renal function was primarily assessed through blood tests, as well as imaging examinations including CT, kidneys, ureters, bladder (KUB) x-rays, and intravenous pyelograms (IVP). The systemic immune-inflammation index (SII) value ($10^9/L$) was calculated according to the blood routine results using the following formula (Jia et al, 2022): $SII = P \times N/L$, where P, N and L represent peripheral platelet, neutrophil and lymphocyte counts, respectively. The glomerular filtration rate (GFR) of creatinine combined with cystatin C was calculated according to the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) $_{Scr-SCysC}$ combined formula (Inker et al, 2021).

Statistical Analysis

All data were processed by SPSS 26.0 (IBM Corp., Armonk, NY, USA). In the normality test of this study, because the sample size of this study is >50 , Kolmogorov-Smirnov (KS) was selected to test the normality of measurement data, and the p value is greater than 0.05 as the standard. The measurement data of normal distribution in this study were expressed as mean \pm standard deviation ($\bar{x} \pm s$). After verifying homogeneity of variance using Levene's test, two independent sample t -tests were conducted for comparisons (corrections were applied when variances were not homogeneous). Skewed measurement data were expressed as median (interquartile range) and analyzed using the non-parametric rank-sum test. Count data were presented as frequency (%). For studies where the total number of samples ($N < 40$) or the theoretical frequency ($T < 1$), Fisher's exact probability method was employed. In cases with ($N > 40$) and ($T > 5$), the Pearson chi-square test was used for analysis.

Since the total number of samples in this study is $N > 40$ and the theoretical frequency is $T > 5$, Pearson chi-square test is used, the Pearson chi-square test is used. Rank data were analyzed using a non-parametric rank-sum test. When patients were grouped according to the grade of embolic vessels, the number of groups exceeded two, necessitating the use of the Kruskal-Wallis H test to assess prognostic factors among patients with varying embolization grades. Subsequent multiple comparisons were conducted on significant factors identified through the Kruskal-Wallis H test to determine the impact of different embolization grades on these prognostic factors. A p -value of <0.05 was deemed statistically significant.

Results

Baseline Characteristics

A total of 105 patients who met the inclusion criteria were recruited, of whom 71 were males and 34 were females, aged 26–90 years (mean age: 63 ± 16 years). No significant difference in baseline data was found between the medical glue group and the traditional group (Table 1).

Table 1. General data analysis of medical adhesive group and traditional group.

Variable		Medical glue group (n = 62)	Traditional group (n = 43)	χ^2/t	<i>p</i>
Gender/case	Male (%)	41 (66.13%)	30 (69.77%)	0.154	0.695
	Female (%)	21 (33.87%)	13 (30.23%)		
Age/years		62.81 ± 15.89	63.37 ± 15.97	-0.179	0.858
Hypertension/case	Yes (%)	45 (72.58%)	28 (65.12%)	0.668	0.414
	No (%)	17 (27.42%)	15 (34.88%)		
Diabetes/case	Yes (%)	10 (16.13%)	4 (9.30%)	1.024	0.312
	No (%)	52 (83.87%)	39 (90.70%)		
Smoking/case	Yes (%)	14 (22.58%)	4 (9.30%)	3.152	0.076
	No (%)	48 (77.42%)	39 (90.70%)		
Drinking/example	Yes (%)	0 (0%)	1 (2.33%)	/	0.410
	No (%)	62 (100%)	42 (97.67%)		
BMI (kg/m ²)		24.64 ± 3.29	24.49 ± 3.70	0.215	0.830

Note: n is the number of cases, $p < 0.05$.

/ indicates that there is no numerical display of fisher's exact test results here. BMI, body mass index.

Comparison of Clinical Data between the Medical Glue Group and the Traditional Group

Single factor analysis revealed statistically significant differences between the two groups in embolization vascular grade, systemic immune-inflammation index (SII) difference, estimated glomerular filtration rate (eGFR) difference, and combined eGFR difference ($p < 0.05$) (Table 2).

The difference between preoperative and postoperative hemoglobin levels in both patient groups was found to be greater than zero, indicating that both treatment methods demonstrated a comparable hemostatic effect. Furthermore, non-parametric test analysis showed no significant difference in the change in hemoglobin levels between the two groups ($p > 0.05$) (Table 3).

Additionally, the postoperative inflammatory response and renal function damage were significantly higher in the combined group compared to the medical glue group (Table 4).

The 105 patients were categorized into four groups based on the grade of embolic blood vessels: grade 2, grade 3, grade 4, and grade 5. A Kruskal-Wallis H test was conducted on the differences of SII, eGFR, and combined eGFR, revealing statistically significant differences among the groups (Table 2). The analysis indicated that the SII difference, eGFR difference, and combined eGFR difference were all statistically significant ($p < 0.05$) (Table 5).

Table 2. Comparison of clinical data between medical adhesive group and combined group.

Variable	Medical glue group (n = 62)	Traditional group (n = 43)	χ^2/Z	<i>p</i>	
Preoperative SII ($10^9/L$)	593.59 (366.14, 1118.19)	636.00 (340.37, 1006.28)	-0.280	0.779	
SII difference ($10^9/L$)	278.65 (28.96, 682.1486)	865.65 (321.82, 2102.76)	-3.375	0.001	
Bleeding site/case	left renal	30	19	0.180	0.671
	right renal	32	24		
Vascular grade/case	grade 2	0	28	/	0.000
	grade 3	0	15		
	grade 4	39	0		
	grade 5	23	0		
Hemoglobin difference	18.00 (13.00, 22.25)	17.00 (13.00, 23.00)	-0.440	0.660	
Urea difference	1.11 (0.36, 2.21)	0.55 (-0.85, 1.80)	-1.763	0.078	
Creatinine difference	6.70 (1.90, 15.93)	11.00 (2.10, 21.80)	-1.062	0.288	
Uric acid difference	15.50 (-45.00, 43.38)	14.20 (-66.00, 48.00)	-0.251	0.802	
eGFR difference	-7.20 (-10.35, -4.50)	-15.39 (-19.30, -11.46)	-6.503	0.000	
Combined eGFR difference	-10.44 (-21.22, -5.87)	-28.89 (-47.22, -18.54)	-4.936	0.000	

Note: n is the number of cases, $p < 0.05$.

/ indicates that there is no numerical display of fisher's exact test results here. SII, systemic immune-inflammation index; eGFR, estimated glomerular filtration rate.

Table 3. Correlation of hemostatic effect of different surgical methods on patients with renal hemorrhage.

Variable	Medical glue group (n = 62)	Traditional group (n = 43)	<i>Z</i>	<i>p</i>
Hemoglobin difference	18.00 (13.00, 22.25)	17.00 (13.00, 23.00)	-0.440	0.660

Note: n is the number of cases, $p < 0.05$.

Table 4. Comparison of clinical data between the medical adhesive group and the combined group.

Variable	Medical glue group (n = 62)	Traditional group (n = 43)	<i>Z</i>	<i>p</i>
SII difference ($10^9/L$)	278.65 (28.96, 682.1486)	865.65 (321.82, 2102.76)	-3.375	0.001
eGFR difference	-7.20 (-10.35, -4.50)	-15.39 (-19.30, -11.46)	-6.503	0.000
Combined eGFR difference	-10.44 (-21.22, -5.87)	-28.89 (-47.22, -18.54)	-4.936	0.000

Note: n is the number of cases, $p < 0.05$.

Table 5. Comparison of clinical data of different grades of vascular embolization group.

Variable	Vascular grade	All patients (n = 105)	H	<i>p</i>
SII difference	grade 2	1015.66 (292.82, 2386.85)	13.727	0.003
	grade 3	670.47 (321.82, 1345.35)		
	grade 4	143.10 (−6.79, 570.66)		
	grade 5	403.68 (85.89, 967.62)		
eGFR difference	grade 2	−15.60 (−22.60, −12.12)	43.451	0.000
	grade 3	−13.67 (−17.89, −10.84)		
	grade 4	−7.43 (−10.42, −4.90)		
	grade 5	−6.00 (−9.20, −3.73)		
Combined eGFR difference	grade 2	−30.01 (−42.23, −19.96)	24.950	0.000
	grade 3	−20.94 (−57.80, −13.61)		
	grade 4	−11.68 (−22.68, −5.91)		
	grade 5	−9.49 (−14.98, −5.64)		

Note: n is the number of cases, $p < 0.05$.

Further multiple comparison results highlighted that the SII difference was significantly different between grade 2 blood vessels and grades 4 and 5 ($p < 0.05$). In terms of the eGFR difference, significant disparities were found between grade 2 blood vessels and grades 3, 4, and 5 ($p < 0.05$). Additionally, the eGFR difference exhibited significant differences between grade 2 blood vessels and grades 4 and 5, as well as between grade 3 blood vessels and grades 4 and 5 ($p < 0.05$) (Table 6).

Case Presentation

Fig. 1: The application of n-butyl-2-cyanoacrylate (NBCA) glue in the interventional embolization of renal hemorrhage is depicted. Angiographic imaging shows that the affected vessels are intermediate branches of the left renal artery, with a rupture localized to grade 4 to grade 5 renal artery vessels. After super-selective catheterization of the ruptured vessels using a microcatheter, NBCA glue was successfully administered for embolization. Post-procedural angiography indicated the resolution of the pseudo-aneurysm and confirmed the absence of contrast agent extravasation.

Fig. 2: This figure illustrates the application of a traditional embolization material, specifically a coil, for the interventional embolization of renal hemorrhage. The angiographic image reveals that the ruptured vessel is the lower trunk of the right renal artery, with a rupture occurring in a grade 3 renal artery vessel. Following super-selective catheterization to target the ruptured vessel, the coil was densely packed into the vessel. Postoperative angiography confirmed the successful occlusion of the distal end of the lower right renal artery.

Discussion

Acute renal hemorrhage is one of the most common emergencies encountered in clinical practice. Rapid and accurate diagnosis, including identification of the

Table 6. Multiple comparisons of different grades of embolization vascular group.

Variable	Vascular grade	Mean value difference	Value 95% CI	<i>p</i>	
SII difference	grade 2	grade 3	269.28	−233.084–1171.639	0.188
		grade 4	951.66	407.938–1495.382	0.001*
		grade 5	724.20	106.474–1341.919	0.022*
	grade 3	grade 2	−469.28	−1171.639–233.084	0.188
		grade 4	482.38	−184.532–1149.297	0.154
		grade 5	254.92	−473.588–983.424	0.489
	grade 4	grade 2	−951.66	−1495.382–407.938	0.001*
		grade 3	−482.38	−1149.297–184.532	0.154
		grade 5	−227.46	−804.563–349.636	0.436
	grade 5	grade 2	−724.20	−1341.919–106.474	0.022
		grade 3	−254.92	−983.425–473.588	0.489
		grade 4	227.46	−349.636–804.563	0.436
eGFR difference	grade 2	grade 3	−8.04	−13.889–2.198	0.007*
		grade 4	−11.48	−16.007–6.669	0.000*
		grade 5	−11.81	2.198–13.889	0.000*
	grade 3	grade 2	8.04	2.198–13.889	0.007*
		grade 4	−3.44	−8.989–2.112	0.222
		grade 5	−3.77	−9.830–2.297	0.221
	grade 4	grade 2	11.48	6.956–16.007	0.000*
		grade 3	3.44	−2.112–8.989	0.222
		grade 5	−0.33	−5.132–4.475	0.892
	grade 5	grade 2	11.81	6.669–16.952	0.000*
		grade 3	3.77	−2.297–9.830	0.221
		grade 4	0.33	−4.474–5.132	0.892
Combined eGFR difference	grade 2	grade 3	−2.73	−14.328–8.868	0.642
		grade 4	−19.16	−28.139– −10.182	0.000*
		grade 5	−18.45	−28.655– −8.254	0.001*
	grade 3	grade 2	2.73	−8.868–14.328	0.642
		grade 4	−16.43	−27.443– −5.418	0.004*
		grade 5	−15.72	−27.754– −3.694	0.011*
	grade 4	grade 2	19.16	10.182–28.139	0.000*
		grade 3	16.43	5.418–27.443	0.004*
		grade 5	0.71	−8.824–10.236	0.883
	grade 5	grade 2	18.45	8.254–28.655	0.001*
		grade 3	15.72	3.694–27.754	0.011*
		grade 4	−0.71	−10.236–8.824	0.883

Note: * indicates that the difference is statistically significant; n is the number of cases, $p < 0.05$.
CI, confidence interval.

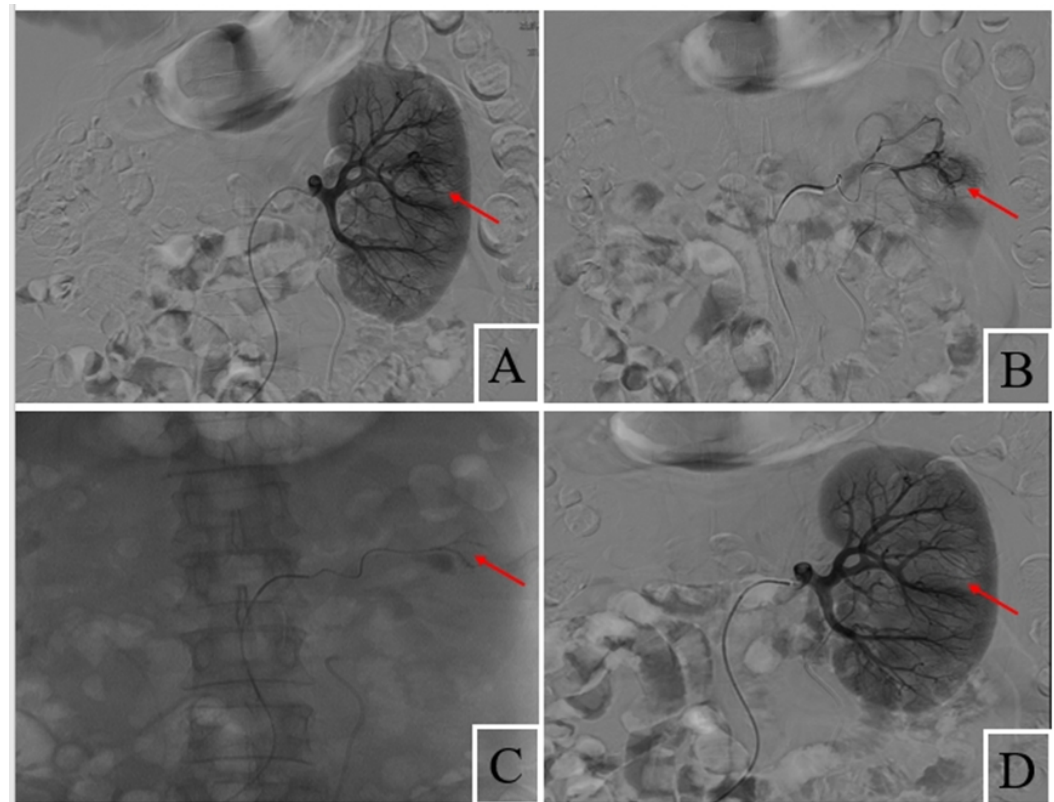


Fig. 1. Application of medical glue in the management of renal hemorrhage. (A) Renal angiography performed after catheter insertion into the middle left renal artery reveals a pseudoaneurysm along with a contrast agent overflow shadow at the lesion site, as indicated by the arrow. (B) The microcatheter to achieve super-selective access to the diseased vessels, with superselective angiography indicating that the ruptured blood vessels are located in renal artery grade 4 to 5 vessels (arrow). (C) The medical glue is injected into the diseased blood vessels through the microcatheter. The arrow in the figure shows that the medical glue is injected into the diseased blood vessel through the microcatheter. (D) Post-injection angiography, confirms the successful resolution of the pseudoaneurysm and the absence of contrast agent extravasation following precise filling, as indicated by the arrow.

bleeding site and type, is crucial for formulating an effective treatment plan. Traditional surgical interventions, such as partial or ipsilateral nephrectomy, can cause significant harm to patients, especially those with risk factors like arteriosclerosis, coagulation dysfunction, diabetes, and hypertension. These patients are particularly prone to recurrent renal hemorrhage post-surgery, complicating prognosis and recovery (Breyer et al, 2008). In contrast, interventional embolization offers advantages such as minimal trauma, significant hemostatic effectiveness, and maximal preservation of renal function, making it the preferred treatment for renal hemorrhage (Güneyli et al, 2015). The present study indicated that the novel embolization material, medical glue, demonstrates a pronounced hemostatic effect compared to traditional materials like coils and gelatin sponge. Notably, there was no significant difference in hemostatic efficacy between the medical glue and traditional groups. This suggests that medical glue not only matches the hemostatic performance of

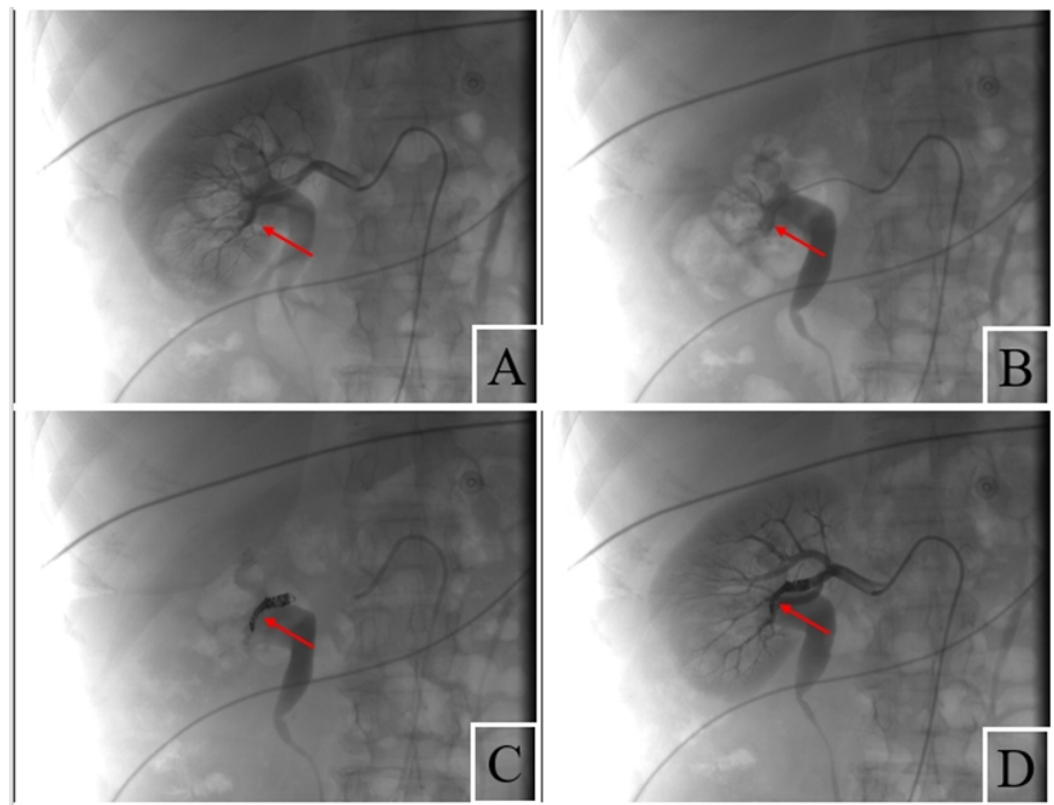


Fig. 2. Application of a coil in the treatment of renal hemorrhage. (A) Renal angiography performed after catheter insertion into the lower trunk of the right renal artery reveals a pseudoaneurysm and a contrast agent overflow shadow at the lesion site, indicated by the arrow. (B) The use of a microcatheter for super-selective access to the diseased vessels, with angiography confirming that the rupture site is located in a grade 3 renal artery blood vessel (arrow). (C) The coil is inserted into the diseased blood vessel through the microcatheter. The arrow in the figure shows that the coil is inserted into the diseased blood vessel through the microcatheter. (D) Post-filling angiography, demonstrating the successful resolution of the pseudoaneurysm and the absence of contrast agent extravasation following precise coil filling, as indicated by the arrow (As shown by the arrow, after the precise filling of the coil, the reexamination of the angiography showed that the false aneurysm shadow and the contrast agent overflow shadow disappeared).

traditional embolization materials but also exerts a lesser impact on postoperative renal function and results in a lower inflammatory response.

NBCA is synthesized using the cyanoacetate formaldehyde method, employing butyl cyanoacetate and paraformaldehyde as primary raw materials, with 1,2-dichloroethane serving as the solvent and pyridine as the catalyst. Compared to traditional sutures and suture nails, NBCA offers several advantages, including excellent antibacterial activity, ease of use, rapid hemostasis, and the elimination of the need for anesthesia or suturing equipment, thereby reducing the risk of needle injuries for surgeons. Initially, its applications included surgical debridement, suturing, and hernia repair. As a permanent liquid embolic agent, NBCA has been successfully utilized in embolizing renal artery hemorrhages. For instance, [Conteggiacomo et al \(2020\)](#) reported a 100% technical success rate in the treatment of 24 cases of iatrogenic renal hemorrhage using NBCA glue. In the current study, 62 pa-

tients treated with NBCA glue alone in the traditional Chinese medicine glue group also achieved a 100% rate of technical and hemostatic success, with no recurrences observed post-operation, aligning with findings from previous studies (Kim et al, 2012; Song et al, 2010).

NBCA possesses several notable advantages. Firstly, it polymerizes quickly upon contact with blood, achieving permanent embolization regardless of the patient's coagulation status. Secondly, due to its liquid flow properties, NBCA can effectively embolize grade 5 target vessels in the kidney through microcatheters, achieving satisfactory results even in cases with pseudoaneurysm shadows or contrast agent extravasation. Thirdly, its ease of use allows for flexible adjustments during the procedure, tailored to the patient's vascular targets. Furthermore, a small volume is sufficient to obtain an effective hemostatic outcome, owing to its low viscosity and high adhesive strength. Additionally, NBCA exhibits strong persistence and stable chemical properties, allowing for its decomposition, absorption, and excretion by the body. Lastly, it demonstrates good biocompatibility and has shown a certain inhibitory effect against bacteria (Carriles et al, 2014).

The present study found statistically significant differences in preoperative and postoperative SII between the two groups, with the median SII difference being significantly lower in the medical glue group compared to the traditional group. SII, a novel inflammatory marker that links neutrophils, lymphocytes, and platelets, is utilized in evaluating the prognosis of various tumours (Yang et al, 2018). It integrates multiple inflammatory markers to reflect inflammation levels and disease progression, making it an effective indicator of the body's inflammatory state and prognosis. Prior study has indicated that SII can predict inflammatory response levels following renal injuries caused by various factors (Jia et al, 2022). Renal hemorrhage can elicit inflammatory reactions within the body, and different embolization materials used in SRAE can further provoke these responses. Our findings demonstrated that the inflammatory response was significantly lower in the medical glue group than in the traditional group.

We hypothesize that this difference can be attributed to two main reasons. Firstly, the biocompatibility of medical glue is superior to that of traditional embolization materials, such as coils, resulting in a lower degree of rejection by the body after implantation (Aksoy et al, 2006). For instance, the synthetic reaction equation is illustrated in Fig. 3 (Kailasnath and Chaloupka, 2002). Nitsch et al (2005) studied the effects of various esters on cell cultures and discovered that methyl ester exhibited high toxicity, impacting cell membrane metabolism and inducing cell death, whereas isobutyl ester had low toxicity, and n-octyl ester was nearly non-toxic. Additionally, medical glue possesses antibacterial properties that can mitigate tissue inflammation (Aksoy et al, 2006).

In contrast, the mechanism of coil embolization primarily induces a cellular reaction upon implantation, leading to local thrombosis. Numerous inflammatory cells, including macrophages and fibroblasts, have been observed in the vascular wall surrounding implanted coils, with phagocytic particles evident in macrophage cytoplasm (Henkes et al, 2003). These inflammatory and phagocytic reactions facilitate local vascular thrombosis, thereby achieving the desired embolization ef-

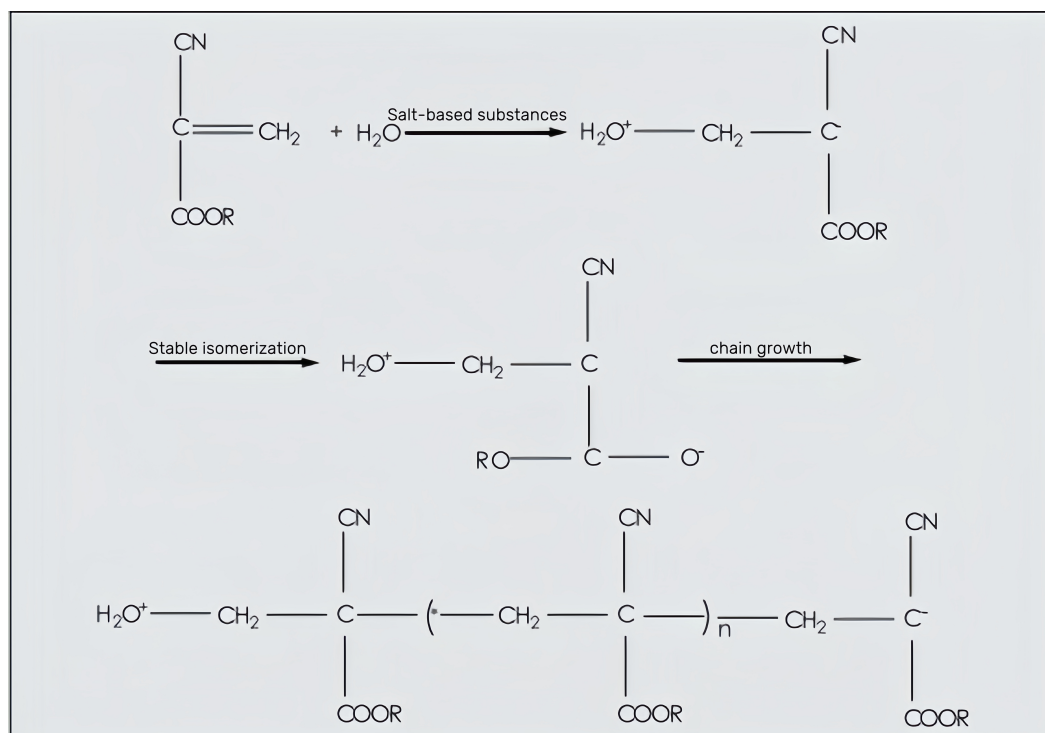


Fig. 3. α -Cyanoacrylate bonding process. Drawing with Adobe Photoshop2023 (Adobe Inc., San Jose, CA, USA). * represents the anionic polymerization reaction between the molecules, that is, the bonding effect.

fect. The area of renal embolization with medical glue is smaller compared to that achieved with spring coils, resulting in reduced renal injury from the embolization process and consequently a lower level of inflammatory response.

GFR is widely recognized as an effective indicator for evaluating renal filtration function. Traditionally, GFR is calculated using formulas based on serum creatinine (Scr) values; however, studies have indicated that these formulas can yield varying degrees of error, making them unreliable for accurately assessing renal filtration in clinical patients. To address this issue, the CKD-EPI in the United States developed a combined formula, $\text{CKD-EPI}_{\text{Scr-SCysC}}$, in 2012, which incorporates both Scr and cystatin C (Cys-c) to calculate eGFR (Inker et al, 2021). Studies have shown that this combined formula significantly outperforms the traditional Scr-based calculation and those relying solely on Cys-c (Betzler et al, 2022; Chehade et al, 2013). In our study, we observed that the GFR values derived from the combined formula were statistically significant following renal embolization in grades 3, 4, and 5 blood vessels, while the traditional formula showed no statistically significant differences (Table 6). This finding indirectly confirms the enhanced accuracy and sensitivity of the combined formula compared to the traditional approach. Additionally, we found that the grade of embolized blood vessels was higher in the medical glue group compared to the traditional group, and this difference was statistically significant. Considering the impact of varying blood vessel grades on GFR, it becomes evident that the medical glue's effect on renal function post-embolization was less detrimental than that of the traditional coil embolization.

The characteristics and economic costs of medical glue and spring coils as embolization materials differ significantly. Medical glue possesses fluidity and strong plasticity, allowing for enhanced controllability during embolization. This enables accurate targeting of the bleeding site without regard to the blood vessel's diameter. In contrast, coils lack the precision required to control the embolization site accurately and are often ineffective for grade 5 blood vessel bleeding, limiting their application.

In terms of economic considerations, the spring coil is more expensive due to the complexity of its material and production process. This is particularly relevant in China, where large and tortuous bleeding arteries typically require multiple coils for complete embolization, increasing the financial burden on patients. Medical glue, on the other hand, is not only cheaper but also more efficient, with fewer units needed for successful treatment. In our study, the average cost of coils used in the traditional group was approximately \$188.27 per coil, with patients requiring at least one coil. In contrast, the medical adhesive group averaged only one medical adhesive, priced at \$130.67. This significant difference in costs effectively reduces the overall medical expenses for patients treated with medical glue.

Furthermore, studies have indicated that coils implanted in the body can restrict patients from undergoing magnetic resonance imaging (MRI) scans rated at 3.0 Tesla or higher, potentially affecting their medical experience (Hug et al, 2000; Levine et al, 2007). Additionally, polyvinyl alcohol particles have been found to be inadequately developed, challenging to use for precise embolization, and associated with high recurrence rates when used alone (Jeon et al, 2016). Notably, renal artery pseudoaneurysms are often located in grade 3–4 branches, which have smaller diameters, making it difficult to maneuver coils effectively and achieve complete embolization. Previous study has also reported that coil embolization may pose a risk of displacing material into the collecting system (Srinivasa et al, 2017).

Similarly, an NBCA adhesive may pose risks such as sticking and reflux due to its strong adhesion and rapid polymerization. Contegiacomo et al (2020) reported a case of NBCA glue reflux to the segmental artery during an operation; however, blood flow in the lumen was restored by balloon compression, which did not result in large-scale renal infarction or renal function damage. In this experiment, there were no complications of tube sticking, reflux, or ectopic embolism among the patients in the traditional Chinese medicine glue group. We believe this may be related to the proportion of medical adhesive used and the strict application of glucose solution prior to its use. Additionally, during medical glue embolization in this study, the operator adjusted the proportion and injection speed of the NBCA glue-iodinated oil mixture according to blood flow velocity and vessel diameter to avoid rapid or slow injections. Rapid injection may lead to reflux, whereas slow injection may damage or decrease the lubricity of the microcatheter, thereby preventing or complicating its withdrawal.

Limitations

This study has several limitations. First, it is a single-center retrospective study. Second, the analysis only included clinical data collected before the operation and

24 hours post-operation, lacking dynamic data monitoring. Finally, renal function was not assessed in patients with acute renal hemorrhage beyond a follow-up period of 3 months.

Conclusion

This study demonstrates that both NBCA glue and traditional embolization materials achieve satisfactory hemostatic effects in cases of renal hemorrhage. However, NBCA glue exhibits a higher level of vascular embolization for renal hemorrhagic lesions and has a lesser impact on renal function post-embolization compared to traditional embolization materials.

Key Points

- In this study, the analysis of hemoglobin levels before and after interventional therapy indicates that NBCA glue exhibits a significant hemostatic effect compared to traditional embolization materials, specifically coils combined with gelatin sponge. However, no statistically significant difference was observed in hemostatic efficacy between the two types of embolization materials.
- The evaluation of the Systemic Immune Inflammation Index (SII) before and after interventional therapy reveals that NBCA glue is associated with a reduced inflammatory response compared to traditional embolization materials following the procedure.
- Through the analysis of the degree of embolization in blood vessels and the glomerular filtration rate calculated using the CKD-EPI_{Scr-SCysC} equation, it is evident that NBCA glue achieves a higher level of vascular embolization in renal hemorrhagic lesions. Furthermore, the impact on renal function post-embolization is less significant compared to traditional embolization materials, resulting in reduced renal function impairment in patients.

Availability of Data and Materials

All data included in this study are available upon request by contact with the corresponding author.

Author Contributions

LPJ: data curation, formal analysis, methodology, writing—original draft, writing—review and editing. QBW and YTZ: data curation, investigation. HMZ and LYR: data curation, investigation. XW: conceptualisation, data curation, project administration, supervision, writing—review and editing. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

All subjects provided written informed consent for inclusion before they participated in the study. This study was conducted in accordance with the Declaration of Helsinki of 1975 and approved by the Ethics Committee of The First Affiliated Hospital of Shihezi University (Ethical approval numbers: KJ2024-207-02).

Acknowledgement

We would like to thank the data collectors and supervisors who were involved in this study and spent their valuable time responding to our study.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

- Aksoy M, Turnadere E, Ayalp K, Kayabali M, Ertugrul B, Bilgic L. Cyanoacrylate for wound closure in prosthetic vascular graft surgery to prevent infections through contamination. *Surgery Today*. 2006; 36: 52–56. <https://doi.org/10.1007/s00595-005-3095-3>
- Betzler BK, Sultana R, He F, Tham YC, Lim CC, Wang YX, et al. Impact of Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) GFR Estimating Equations on CKD Prevalence and Classification Among Asians. *Frontiers in Medicine*. 2022; 9: 957437. <https://doi.org/10.3389/fmed.2022.957437>
- Bookstein JJ, Ernst CB. Vasodilatory and vasoconstrictive pharmacoangiographic manipulation of renal collateral flow. *Radiology*. 1973; 108: 55–59. <https://doi.org/10.1148/108.1.55>
- Breyer BN, McAninch JW, Elliott SP, Master VA. Minimally invasive endovascular techniques to treat acute renal hemorrhage. *The Journal of Urology*. 2008; 179: 2248–2252; discussion 2253. <https://doi.org/10.1016/j.juro.2008.01.104>
- Carriles YR, Brito RA, Sánchez RM, Acevedo ES, Domínguez PR, Mueller WD. n-Butyl cyanoacrylate synthesis. A new quality step using microwaves. *Molecules*. 2014; 19: 6220–6227. <https://doi.org/10.3390/molecules19056220>
- Chehade H, Cachat F, Jannot AS, Meyrat BJ, Mosig D, Bardy D, et al. Combined serum creatinine and cystatin C Schwartz formula predicts kidney function better than the combined CKD-EPI formula in children. *American Journal of Nephrology*. 2013; 38: 300–306. <https://doi.org/10.1159/000354920>
- Contegiacomo A, Amodeo EM, Cina A, Di Stasi C, Iezzi R, Coppolino D, et al. Renal artery embolization for iatrogenic renal vascular injuries management: 5 years' experience. *The British Journal of Radiology*. 2020; 93: 20190256. <https://doi.org/10.1259/bjr.20190256>
- Güneyli S, Gök M, Bozkaya H, Çınar C, Tizro A, Korkmaz M, et al. Endovascular management of iatrogenic renal arterial lesions and clinical outcomes. *Diagnostic and Interventional Radiology*. 2015; 21: 229–234. <https://doi.org/10.5152/dir.2014.14286>
- Henkes H, Brew S, Miloslavski E, Fischer S, Tavrovski I, Kühne D. The Underlying Mechanisms of Endovascular Exclusion of Intracranial Aneurysms by Coils. How Important is Electrothrombosis? *Interventional Neuroradiology*. 2003; 9: 127–140. <https://doi.org/10.1177/159101990300900202>
- Hill H, Chick JFB, Hage A, Srinivasa RN. N-butyl cyanoacrylate embolotherapy: techniques, complications, and management. *Diagnostic and Interventional Radiology*. 2018; 24: 98–103. <https://doi.org/10.5152/dir.2018.17432>

- Hug J, Nagel E, Bornstedt A, Schnackenburg B, Oswald H, Fleck E. Coronary arterial stents: safety and artifacts during MR imaging. *Radiology*. 2000; 216: 781–787. <https://doi.org/10.1148/radiology.216.3.r00se03781>
- Inker LA, Eneanya ND, Coresh J, Tighiouart H, Wang D, Sang Y, et al. New Creatinine- and Cystatin C-Based Equations to Estimate GFR without Race. *The New England Journal of Medicine*. 2021; 385: 1737–1749. <https://doi.org/10.1056/NEJMoa2102953>
- Jeon CH, Seong NJ, Yoon CJ, Byun SS, Lee SE. Clinical results of renal artery embolization to control post-operative hemorrhage after partial nephrectomy. *Acta Radiologica Open*. 2016; 5: 2058460116655833. <https://doi.org/10.1177/2058460116655833>
- Jia L, Li C, Bi X, Wei F, Meng J, Sun G, et al. Prognostic Value of Systemic Immune-Inflammation Index among Critically Ill Patients with Acute Kidney Injury: A Retrospective Cohort Study. *Journal of Clinical Medicine*. 2022; 11: 3978. <https://doi.org/10.3390/jcm11143978>
- Kailasnath P, Chaloupka JC. Quantitative assessment of polymerization-binding mechanics of cyanoacrylates: model development and validation. *AJNR. American Journal of Neuroradiology*. 2002; 23: 772–778.
- Kim J, Shin JH, Yoon HK, Ko GY, Gwon DI, Kim EY, et al. Transcatheter renal artery embolization with N-butyl cyanoacrylate. *Acta Radiologica*. 2012; 53: 415–421. <https://doi.org/10.1258/ar.2012.110595>
- Levine GN, Gomes AS, Arai AE, Bluemke DA, Flamm SD, Kanal E, et al. Safety of magnetic resonance imaging in patients with cardiovascular devices: an American Heart Association scientific statement from the Committee on Diagnostic and Interventional Cardiac Catheterization, Council on Clinical Cardiology, and the Council on Cardiovascular Radiology and Intervention: endorsed by the American College of Cardiology Foundation, the North American Society for Cardiac Imaging, and the Society for Cardiovascular Magnetic Resonance. *Circulation*. 2007; 116: 2878–2891. <https://doi.org/10.1161/CIRCULATIONAHA.107.187256>
- Limtrakul T, Rompsaithong U, Ahojja A, Kiatsopit P, Lumbiganon S, Pachirat K, et al. Renal Artery Embolization for Acute Renal Hemorrhage: A Single-Center Experience. *Research and Reports in Urology*. 2020; 12: 315–319. <https://doi.org/10.2147/RRU.S263012>
- Muller A, Rouvière O. Renal artery embolization-indications, technical approaches and outcomes. *Nature Reviews. Nephrology*. 2015; 11: 288–301. <https://doi.org/10.1038/nrneph.2014.231>
- Nitsch A, Pabyk A, Honig JF, Verheggen R, Merten HA. Cellular, histomorphologic, and clinical characteristics of a new octyl-2-cyanoacrylate skin adhesive. *Aesthetic Plastic Surgery*. 2005; 29: 53–58. <https://doi.org/10.1007/s00266-004-0096-3>
- Schwartz MJ, Smith EB, Trost DW, Vaughan ED, Jr. Renal artery embolization: clinical indications and experience from over 100 cases. *BJU International*. 2007; 99: 881–886. <https://doi.org/10.1111/j.1464-410X.2006.06653.x>
- Song HH, Won YD, Kim YJ. Transcatheter N-butyl cyanoacrylate embolization of pseudoaneurysms. *Journal of Vascular and Interventional Radiology*. 2010; 21: 1508–1511. <https://doi.org/10.1016/j.jvir.2010.05.022>
- Srinivasa RN, Chick JFB, Hage A, Ramamurthi A, Wolf JS, Jr, Gemmete JJ, et al. Erosion of Embolization Coils into the Renal Collecting System: Removal with Prone Transradial Renal Arteriography and Nephroscopy. *Journal of Endourology*. 2017; 31: 1019–1025. <https://doi.org/10.1089/end.2017.0554>
- Yang R, Chang Q, Meng X, Gao N, Wang W. Prognostic value of Systemic immune-inflammation index in cancer: A meta-analysis. *Journal of Cancer*. 2018; 9: 3295–3302. <https://doi.org/10.7150/jca.25691>