

Prostatic Artery Embolization Using N-butyl Cyanoacrylate for Benign Prostatic Hyperplasia: A Two-center Prospective Study

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Abstract

Background

Benign prostatic hyperplasia (BPH) is a common condition affecting aging men, leading to bothersome lower urinary tract symptoms (LUTS). Prostatic artery embolization (PAE) has emerged as a minimally invasive treatment option. While particle embolization is widely used, the application of liquid embolic agents in PAE, particularly in the Vietnamese context, remains underexplored. This study aimed to evaluate the outcomes of PAE using N-butyl-2-cyanoacrylate (NBCA) in patients with BPH.

Methods

This two-center, prospective, observational study included 69 patients with symptomatic BPH undergoing PAE with NBCA. Clinical, laboratory, and imaging parameters were collected at baseline and at the 3-month and 6-month follow-up visits. Primary outcomes included changes in International Prostate Symptom Score (IPSS), Quality of Life (QoL) score, prostate-specific antigen (PSA) level, and prostate volume. Secondary outcomes included changes in International Index of Erectile Function (IIEF) score, post-void residual urine volume (PVR), procedural parameters (procedure time, fluoroscopy time, radiation dose, dose-area product, use of cone-beam CT [CBCT], and use of coils), and complication rate. Paired t-tests were used for statistical analysis.

Results

Significant improvements were observed in IPSS, QoL, prostate volume, PSA, and PVR at both 3 and 6 months post-procedure (all $p < 0.001$). Mean IPSS decreased from 22.2 ± 7.0 at baseline to 8.0 ± 4.1 at 3 months and 7.3 ± 4.5 at 6 months. The clinical success rate was 97.1%. Complications, predominantly minor (Clavien-Dindo grade 1 or 2), occurred in 58.0% of patients.

Conclusion

PAE using NBCA is a safe and effective treatment for BPH, leading to significant and sustained improvements in LUTS, QoL, prostate volume, and PSA levels, with a favorable safety profile.

INTRODUCTION

Benign prostatic hyperplasia (BPH) is a common non-malignant enlargement of the prostate affecting aging men and frequently causing lower urinary tract symptoms (LUTS)^{1,2}. When conservative management fails or complications occur, surgical intervention is indicated. Although transurethral

resection of the prostate (TURP) is the gold standard, its associated risks (e.g., bleeding, transurethral resection syndrome, retrograde ejaculation) have driven the adoption of less invasive alternatives³.

Prostatic artery embolization (PAE) has emerged as a promising minimally invasive treatment for BPH. Numerous studies and meta-analyses worldwide have demonstrated the efficacy and safety of PAE^{4,5}. In Vietnam, PAE was first introduced at Bach Mai Hospital in 2014⁶. Traditionally, most PAE procedures, both globally and in Vietnam, have utilized particulate embolic agents^{7,8}.

However, a notable drawback of particulate agents is the slow injection rate required to prevent premature occlusion of the main prostatic artery trunk and reflux of particles into non-target arteries, often resulting in prolonged fluoroscopy time and increased radiation exposure for both patients and operators. Furthermore, recurrence of LUTS after particle embolization remains a concern^{9,10}. These challenges have motivated the exploration of alternative embolic agents, such as liquid embolic agents (e.g., NBCA, Onyx), which offer several potential advantages, including easier intraprocedural visualization, rapid embolization, and homogeneous filling of the vascular bed, potentially reducing the risk of recanalization¹¹.

While some international studies have evaluated the efficacy of liquid embolic agents in PAE and compared them with particulate agents^{12,13}, data remain scarce, particularly in Vietnam, regarding the outcomes of PAE using liquid embolic agents. This study therefore aimed to investigate the outcomes of PAE using NBCA for BPH, with the following objectives:

1. To describe the clinical, paraclinical, and procedural characteristics of patients with BPH undergoing PAE with NBCA.
2. To evaluate the treatment outcomes, efficacy, and safety of PAE using NBCA.

METHODS

Study Design and Population

This was a two-center, prospective, observational study conducted at the Institute of Diagnostic and Interventional Radiology, Bach Mai Hospital, and the Department of Radiology, Hong Ngoc – Phuc Truong Minh General Hospital, from September 2024 to December 2025. The study population comprised male patients diagnosed with symptomatic BPH who underwent PAE with NBCA. Ethical approval for the study was obtained from the Institutional Review Board of Hanoi Medical University, and all participants provided written informed consent prior to enrollment.

Inclusion criteria:

- Male patients ≥ 50 years old with LUTS secondary to BPH.
- IPSS ≥ 8 (moderate to severe symptoms).

- Prostate volume ≥ 30 mL.
- Failure of medical therapy or contraindications to surgery.
- No evidence of prostate cancer (PSA < 4 ng/mL or negative prostate biopsy).
- No active urinary tract infection.
- No severe renal insufficiency.

Exclusion criteria:

- Known prostate cancer.
- Severe atherosclerosis of pelvic arteries precluding catheterization.
- Allergy to contrast media.
- Uncontrolled coagulopathy.

Prostatic Artery Embolization Procedure

All PAE procedures were performed by experienced interventional radiologists. Patients received local anesthesia, and a unilateral femoral artery approach was typically used. A 5-Fr sheath was inserted, and a 5-Fr Cobra or Simmons catheter was advanced into the internal iliac artery. Digital subtraction angiography (DSA) was performed to identify the prostatic arteries and their anastomoses. A microcatheter (e.g., 2.7-Fr Progreat) was then selectively advanced into the prostatic artery. Non-target embolization risks, particularly to the bladder, rectum, and erectile arteries, were carefully assessed. If significant anastomoses were identified, attempts were made to occlude them with microcoils or to avoid embolization of the specific prostatic artery branch involved. CBCT was performed when vascular anatomy was unclear.

NBCA was mixed with lipiodol at a dilution of 1:8 to 1:10. This mixture was injected under continuous fluoroscopic monitoring until occlusion of the target prostatic arterial branches was achieved, with minimal reflux at the microcatheter tip.

Data Collection and Outcome Measures

Clinical, laboratory, and imaging data were collected at baseline (pre-procedure) and at the 3-month and 6-month follow-up visits. The following variables were recorded:

Baseline characteristics

age (years); prostate volume (mL); post-void residual urine volume (mL); total PSA (ng/mL); IPSS; QoL score; IIEF score; presence of acute urinary retention.

Procedural parameters

procedure time (minutes); fluoroscopy time (minutes); radiation dose (mGy); dose-area product (DAP, Gy·cm²); use of CBCT; use of coils.

Follow-up outcomes (3-month and 6-month)

IPSS; QoL score; IIEF score; PSA; prostate volume; post-void residual urine volume; complications classified by the Clavien-Dindo classification; clinical success.

According to the CIRSE 2019 standards, clinical success was defined as an IPSS score < 18 with a $\geq 25\%$ reduction, and a QoL score ≤ 3 with at least a 1-point decrease compared with baseline. For patients presenting with acute urinary retention and an indwelling catheter, clinical success was defined as successful catheter removal with the ability to void spontaneously⁸.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics and procedural parameters. Continuous variables were presented as mean $\pm$ standard deviation (SD) or median and interquartile range (IQR), as appropriate, while categorical variables were presented as frequencies and percentages. Paired t-tests were used to compare baseline values with 3-month and 6-month follow-up values for continuous outcome measures (IPSS, QoL, IIEF, PSA, prostate volume, and post-void residual urine volume). A p-value < 0.05 was considered statistically significant. All statistical analyses were performed using Python (Pandas, NumPy, and SciPy libraries).

RESULTS

Patient Characteristics and Procedural Parameters

A total of 69 patients underwent PAE with NBCA. The mean age was 70.8 ± 8.1 years. Baseline clinical and paraclinical characteristics are summarized in Table 1. The mean prostate volume was 77.2 ± 30.7 mL, and the mean total PSA was 12.3 ± 15.6 ng/mL. Patients presented with moderate to severe LUTS, indicated by a mean IPSS of 22.2 ± 7.0 and a mean QoL score of 4.0 ± 0.7 . The mean IIEF score was 8.6 ± 4.8 .

Table 1
Baseline Characteristics and Procedural Parameters (N = 69)

Variable	Mean $\pm$ SD / n (%)
Patient Characteristics	
Age (years)	70.8 $\pm$ 8.1
Prostate volume (mL)	77.2 $\pm$ 30.7
Post-void residual urine volume (mL)	43.7 $\pm$ 42.0
Total PSA (ng/mL)	12.3 $\pm$ 15.6
IPSS	22.2 $\pm$ 7.0
QoL score	4.0 $\pm$ 0.7
IIEF score	8.6 $\pm$ 4.8
Acute urinary retention	19 (27.54%)
Procedural Parameters	
Intervention time (minutes)	74.5 $\pm$ 24.0
Fluoroscopy time (minutes)	25.1 $\pm$ 15.3
Radiation dose (mGy)	1045.4 $\pm$ 454.7
DAP (Gy·cm ²)	193.9 $\pm$ 77.4
Use of CBCT	2 (2.89%)
Coil embolization	9 (13.04%)
Clinical success rate	67 (97.1%)

Procedural parameters showed a mean intervention time of 74.5 $\pm$ 24.0 minutes, a mean fluoroscopy time of 25.1 $\pm$ 15.3 minutes, and a mean radiation dose of 1045.4 $\pm$ 454.7 mGy. The mean dose-area product (DAP) was 193.9 $\pm$ 77.4 Gy·cm². CBCT was used in 2 patients (2.89%). Nine patients (13.04%) received coil embolization. The clinical success rate, defined according to CIRSE criteria⁸, was 97.1%. Among the 19 patients with acute urinary retention who required catheterization prior to PAE, 18 achieved successful catheter removal (94.74%).

Clinical Outcomes at 3 and 6 Months

Significant improvements were observed in all primary and secondary clinical parameters at both the 3-month and 6-month follow-ups compared with baseline (Table 2).

Table 2
Clinical Outcomes at Baseline, 3 Months, and 6 Months Post-PAE

Variable	Baseline (Mean ± SD)	3 Months (Mean ± SD)	p (vs. Baseline)	6 Months (Mean ± SD)	p (vs. Baseline)
IPSS	22.2 ± 7.0	8.0 ± 4.1	< 0.001	7.3 ± 4.5	< 0.001
QoL score	4.0 ± 0.7	2.0 ± 0.7	< 0.001	1.7 ± 0.8	< 0.001
IIEF score	8.6 ± 4.8	8.7 ± 5.1	0.88	8.9 ± 5.4	0.88
Total PSA (ng/mL)	12.3 ± 15.6	3.3 ± 2.3	< 0.001	3.1 ± 2.4	< 0.001
Prostate volume (mL)	77.2 ± 30.7	54.2 ± 27.6	< 0.001	49.0 ± 20.1	< 0.001
Post-void residual (mL)	43.7 ± 42.0	23.1 ± 22.0	< 0.001	19.4 ± 21.1	< 0.001

At 3 months, mean IPSS decreased significantly to 8.0 ± 4.1 ($p < 0.001$), and mean QoL score improved to 2.0 ± 0.7 ($p < 0.001$). Prostate volume decreased to 54.2 ± 27.6 mL ($p < 0.001$), and PSA decreased to 3.3 ± 2.3 ng/mL ($p < 0.001$). Post-void residual urine volume also decreased significantly, to 23.1 ± 22.0 mL ($p < 0.001$). The IIEF score remained stable at 8.7 ± 5.1 ($p = 0.88$, not significant).

These improvements were sustained at 6 months. Mean IPSS further decreased to 7.3 ± 4.5 ($p < 0.001$ vs. baseline), and QoL score improved to 1.7 ± 0.8 ($p < 0.001$ vs. baseline). Prostate volume continued to decrease, to 49.0 ± 20.1 mL ($p < 0.001$ vs. baseline), and PSA was 3.1 ± 2.4 ng/mL ($p < 0.001$ vs. baseline). Post-void residual urine volume was 19.4 ± 21.1 mL ($p < 0.001$ vs. baseline). The IIEF score at 6 months was 8.9 ± 5.4 ($p = 0.88$, not significant).

Complications

Complications were assessed using the Clavien-Dindo classification. The overall complication rate was 58.0% (40/69 patients), all of which were minor (grade 1: 34 patients [49.3%]; grade 2: 6 patients [8.7%]), with no major complications (grade ≥ 3) reported; 29 patients (42.0%) experienced no complications. Specific minor adverse events included mild rectal pain, dysuria, and hematuria. Retrograde ejaculation was documented in 3 patients (4.3%).

DISCUSSION

This study provides valuable insights into the efficacy and safety of prostatic artery embolization using NBCA for the treatment of BPH in a Vietnamese cohort. Our findings demonstrate significant and sustained improvements in LUTS, QoL, prostate volume, and PSA levels at both the 3-month and 6-month follow-ups. These results reinforce the growing body of evidence supporting NBCA as a viable embolic alternative to conventional particulate agents in PAE for BPH^{11–13}.

One of the key advantages of NBCA, as highlighted in the introduction, is the potential for more controlled and rapid embolization, which may contribute to reduced fluoroscopy time and radiation exposure. Our procedural data, with a mean fluoroscopy time of 25.1 minutes and a mean procedure time of 74.5 minutes, are within the range reported in the literature for PAE using NBCA¹⁴. Although this study lacked a direct control group of patients undergoing particulate embolization, cross-referencing with published literature indicates that PAE using NBCA markedly reduces fluoroscopy time and overall procedural duration^{15,16}. In addition to reducing fluoroscopy and procedural times, NBCA has also been shown to lower total radiation dose, as demonstrated in comparative studies between particle and NBCA embolization by Salet et al. and Hijazi et al.^{13,17}.

In our study, the proportion of patients requiring coil embolization was 13.04%, which is lower than the 26.2% reported by Bhatia et al. in their series of 122 PAE cases evaluating the role of protective coiling¹⁸. Our overall coiling rate is comparable to the 12.0% (26/216 patients) reported by Maclean et al., which accounted solely for protective coiling of penile anastomoses¹⁹. This relatively low requirement for coil usage in our cohort may be attributable to two main factors. First, the limited availability and high cost of coils in our setting presented practical economic constraints. Second, the intrinsic technical characteristics of NBCA may have played a role: NBCA reduces the risk of opening collateral pathways during injection, thereby inherently minimizing the need for protective coiling (Fig. 1). Furthermore, when the microcatheter was positioned close to non-target branches supplying adjacent structures (such as the rectum, penis, or bladder), real-time fluoroscopic visualization of the glue cast provided sufficient operator confidence to achieve safe, targeted embolization without resorting to protective coils.

The high clinical success rate of 97.1% observed in our cohort is encouraging and suggests that NBCA-based PAE is a highly effective procedure. Regarding clinical efficacy in patients presenting with acute urinary retention, our cohort demonstrated a remarkably high catheter-free rate, with successful trial without catheter achieved in 94.74% (18/19) of cases following NBCA embolization.

Regarding safety, the overall complication rate was approximately 58%, all of which were minor, with no major adverse events. Regarding ejaculatory function, retrograde ejaculation was observed in only 4.3% (3/69) of patients in our study. This finding highlights a significant clinical advantage of NBCA-based PAE over conventional surgical interventions such as TURP, which is associated with retrograde ejaculation rates as high as 53–75%²⁰. Furthermore, with respect to overall erectile function evaluated by the IIEF score, no statistically significant post-procedural changes were observed in our cohort.

Our study has several limitations. First, it is a prospective observational study without a control group comparing NBCA with particulate agents, which limits our ability to directly compare the efficacy and safety profiles of different embolic materials. Second, the follow-up period was limited to 6 months; longer-term follow-up is necessary to assess the durability of treatment effects and the incidence of late complications or symptom recurrence. Third, although the sample size was adequate to demonstrate significant improvements, a larger cohort would allow more robust statistical power and subgroup

analyses. Finally, the study was conducted in a specific population in Vietnam, and the generalizability of these findings to other populations may require further validation.

Despite these limitations, this study contributes real-world data on the use of NBCA for PAE in BPH, particularly in a region where such data remain scarce. The positive outcomes observed suggest that NBCA-based PAE is a safe and effective treatment option, offering a valuable alternative for patients with symptomatic BPH.

CONCLUSION

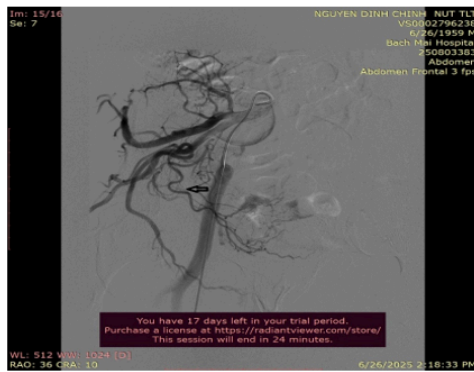
Prostatic artery embolization using NBCA is a safe and effective treatment for benign prostatic hyperplasia, leading to significant improvements in lower urinary tract symptoms, quality of life, prostate volume, and PSA levels at 3 and 6 months post-procedure. The procedure demonstrated a high clinical success rate (97.1%) with a favorable safety profile, primarily involving minor and manageable complications (58.0% overall). These findings support the continued exploration and adoption of NBCA-based PAE as a valuable minimally invasive option for the management of BPH.

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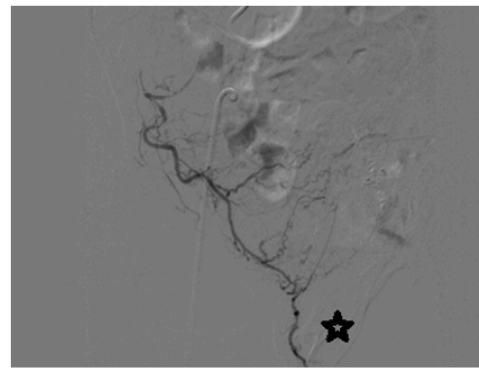
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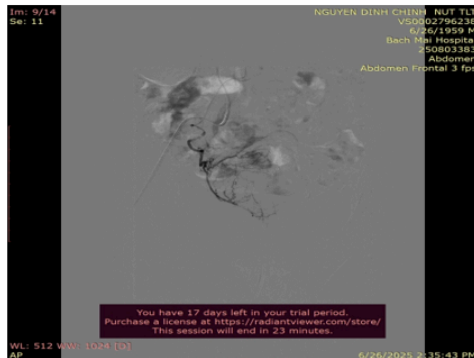
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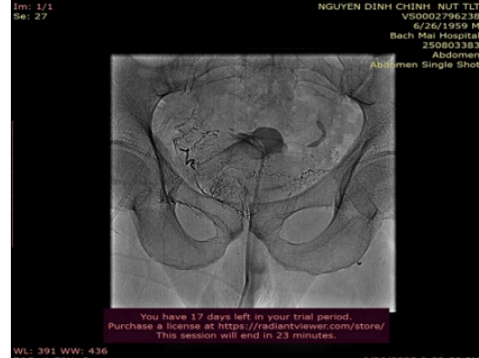
A



B



C



D

Figure 1. Illustrative case of prostatic artery embolization using NBCA. (A) Angiogram showing the right prostatic artery (arrow) originating from a common trunk with the vesical artery. (B) Selective right prostatic angiogram demonstrating a prominent collateral to the penis. (C) Although intra-arterial nitroglycerin-induced vasodilation led to angiographic disappearance of this collateral, particulate embolization would carry a near-certain risk of its recanalization, necessitating protective coil placement. (D) Embolization performed using NBCA under real-time fluoroscopic monitoring demonstrates complete occlusion without glue reflux into the penile base.

Figure 1

See image above for figure legend.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1.docx](#)
- [Table2.docx](#)
- [DataSharingStatementFormPAEwithNBCAforBPH.docx](#)
- [ICMJECOIDisclosureall9authors.docx](#)
- [STROBEChecklist.docx](#)
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