N-Butyl Cyanoacrylate Glue Versus Nonspherical Polyvinyl Alcohol Particles For Prostatic Arterial Embolization To Treat Benign Prostatic Hyperplasia: Safety and Efficacy

Bilal Ahmad Hijazi[1,2]*, Hai-Bin Shi[1], Sheng Liu[1], Turki Atia Alqurashi[2], Zakir Jamal Sabri[2]

Purpose: Our aim is to compare N-butyl cyanoacrylate (NBCA) glue and non-spherical polyvinyl alcohol (PVA) particles for prostatic artery embolization (PAE) for patients with benign prostatic hyperplasia (BPH) to treat lower urinary tract symptoms (LUTS) and report their feasibility, safety, and short-term effectiveness.

Materials and Methods: 110 patients (mean age: 72.6 years) with BPH related to LUTS were divided into two groups, PAE was performed in one group with 250 - 355 µm non-spherical PVA particles. Whereas, the other group received a mixture of NBCA glue/ lipiodol for PAE.

Results: PAE was technically successful in all 110 patients (100 %). During 6 months follow up, we found that in patients who received NBCA glue, the mean of prostatic volume (PV) was significantly reduced compared to baseline (67.1 ± 8.5 to 40.2 ± 5.4), International Prostate Symptom Score (IPSS) (25.7 ± 4.3 to 7.2 ± 1.09), Quality of life (QoL) (4.43 ± 0.27 to 1.58 ± 2.27); whereas, the mean of Peak urinary flow (Qmax) increased significantly from baseline to 6 months (8.6 ± 2.3 to 15.4 ± 2.3), International Index of Erectile Function (IIEFS) (9.46 ± 1.51 to 19.3 ± 1.33). Meanwhile, non-spherical PVA particles used in the other group show that PV significantly reduced from baseline to 6 months (68.2 ± 8.32 to 38.8 ± 6.13), IPSS (25.0 ± 3.59 to7.24 ± 0.83), QoL (4.43 ± 0.24 to1.56 ± 0.55). The mean for Qmax increased from baseline to 6 months (7.19 ± 1.67 to15.1 ± 2.42), IIEFS (9.22 ± 1.30 to 19.5 ± 0.96).

Conclusion: PAE with NBCA glue and non-spherical PVA particles is feasible, safe, and effective for patients with BPH related-LUTS. This gives the physicians options to choose between embolizing agents based on the architecture of the prostatic artery.

Keywords: lower urinary tract symptoms; benign prostate hyperplasia; prostate artery embolization; NCBA glue; non-spherical polyvinyl alcohol

INTRODUCTION

Benign prostate hyperplasia (BPH) is one of the most frequent conditions affecting the male genitourinary system, and results in lower urinary tract symptoms (LUTS), including a feeling of incomplete emptying, hesitancy, reduced urine stream, urinary frequency, and nocturia. It is common in males over 50 years of age.[1] Those with moderate-to-severe LUTS may benefit from 5-α-reductase inhibitors or combination therapy (5 -α-reductase inhibitors plus α-blocker).[2,3] this log-term treatment can be useful, but has side effectssuch as erectile dysfunction, impotence, and reduced libido.[4,5] Yet, there will always be patients whose treatments fail.

Transurethral resection of the prostate (TURP) surgery is the gold-standard therapy for BPH.[6] Other minimal invasive options include transurethral microwave therapy (TUMT), and transurethral needle ablation (TUNA). Nevertheless, can have side effects such as retrograde ejaculation, impotence, and bleeding.[7]

The PAE has early and midterm outcomes in lowering LUTS and enhancing QoL.[8] Furthermore, it has been determined that PAE, is safer and more successful than TURP because of less blood loss and a shorter hospital stay.[9]

The majority of investigations rely on the free-flow injection of non-spherical PVA with a diameter of 300 – 500 µm. NBCA has a high level of attention among interventional radiologists due to its favorable effectiveness and biological toleration. Particularly noteworthy is the outstanding effectiveness NBCA has demonstrated in reducing active bleeding from peripheral arteries.[10]

NBCA is a liquid that polymerizes when it comes in contact with ion-rich fluids like blood.[11,12] Due to its excellent tension resistance and bacteriostatic and hemostatic properties, it is one of the most widely used tissue adhesives.[13] Fast hemostasis is made possible by quick polymerization, which is very helpful in patients with hemodynamic instability. In narrow or tortuous arteries that are challenging to catheterize, NBCA facilitates distal embolization by a flow-directed technique because of its liquid state.[14] NBCA and com-

[1]Department of Interventional Radiology, Jiangsu Province Hospital, The First Affiliated Hospital Nanjing Medical University, People's Republic of China.
[2]Department of Imaging & Interventional Radiology, King Abdulaziz Hospital and Research Center, KSA.
*Correspondence: Department of Interventional Radiology, Jiangsu Province Hospital, The First Affiliated Hospital Nanjing Medical University, People's Republic of China. E-mail: shihb@njmu.edu.cn.
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Table 1. Baseline characteristics.

Name	Range
Age, years	54-90
IIEF score	6.4-11.78
IPSS score	18.04-35.89
MRI Prostate Volume, mL	50.12-83
PSA, ng/mL	4.2-9.87
Qmax, mL/s	2.4-9.95
QoL score	4-5.03

Abbreviations: MRI, Magnetic Resonance Imaging; IPSS, International Prostatic Symptoms Score; Qmax, maximum urinary flow rate; PSA, prostate-specific antigen; QoL, quality of life; IIEFS, International Index of Erectile Function score.

monly used non-spherical PVA particles are two types of embolic agents that have not yet been the subject of any studies comparing their effects on PAE outcomes. Our study's objective was is to compare the feasibility, safety, and short-term effectiveness of NBCA glue and non-spherical PVA particles as embolic agents for PAE in patients with symptomatic BPH.

MATERIALS AND METHODS

Study Population

The study received approval from the hospital's ethical committee. Urologists reviewed each patient and offered them other treatment options, such as TURP. 110 patients from two groups of a tertiary center received PAE who were presented with LUTS due to BPH between July 2019 and June 2021. Their age ranged from 54 to 90 years; the mean was (72.6 years).

Inclusion criteria were LUTS due to BPH Resistance to medical therapy for > 6 months, prostate volume (PV) > 30 ml, IPSS $\geq$ 18 points, QoL score $\geq$ 3, Qmax $\leq$ 12 ml/s.

The exclusion criteria included malignancy (determined by prostate specific antigen (PSA), digital rectal examination, transrectal ultrasound (TRUS) biopsy, and MRI in all patients), chronic renal failure, and any urinary issue unrelated to BPH.

Pelvic MRI was used as part of the standard diagnostic process for BPH to measure the volume of the prostate. The prostate is examined by MRI with a 1.5-T or 3-T magnetic field intensity. T2-weighted sequences are used to measure the whole prostatic dimensions. Computing the prostate volume using the equation (transverse diameter x anteroposterior diameter x craniocaudal diameter x .52).

The sample size was determined based on the specific objectives of our study. We aimed to detect meaningful and clinically relevant effects or associations within the scope of our research question. The sample size calculation took into account the desired statistical power to detect these effects, as well as the expected effect sizes or differences. We also considered practical and logistical constraints when determining the sample size. This included factors such as the availability of eligible participants, resources required for data collection and analysis, and the time frame of the study.

Procedures

All patients stopped using their BPH medications, and prophylactic antibiotics were given. An experienced interventional radiologist utilized the high-resolution digital subtraction angiography suit (Axiom Artis; Siemens, Erlangen, Germany) to perform PAE. Under local anesthetic, right unilateral femoral technique was used for PAE.

Initially, a pelvic angiography was done to assess the internal iliac and prostatic arteries. Then, 5-F angiographic cobra catheter (Yashiro catheter; Terumo, Tokyo, Japan) was used in the anterior-posterior (AP), ipsilateral 35° oblique, and caudal-cranial angulation of -10° views with non-ionic contrast media (Iomeron 350; Bracco, Milan, Italy) to achieve selected bilateral internal iliac arteriograms.

Prostatic arteriography was carried out in the AP projection and catheterization of super-selective prostatic arteries done by using a 2.0-F microcatheter (Progreat; Terumo, Tokyo, Japan) and a 0.014-inch guide wire (Transcend; Boston Scientific, Natick, USA).

Prostatic arteries are embolized using the (PErFecTED Method) to near stasis after passing all collateral arteries, then navigated further into the parenchymal branches and embolized to complete stasis.

One group of patients underwent embolization using a microcatheter positioned inside the feeding artery, 250 - 355µm non-spherical PVA particles (Contour; Boston Scientific, Natick, USA) diluted in 20 mL of normal saline and 30 mL of contrast medium in a 2: 3 solutions, and the particles were gradually injected slowly until they reached an endpoint of near stasis of contrast agent (**Figure 1**). While in the other group, once the microcatheter was positioned within the supplying artery, 2 mg of isosorbide dinitrate (Risordan, 10 mg/10 mL vial) was given intra-arterially to cause vasodilation. To create the substance radio-opaque, NBCA glue (Glubran 2, GEM; Viareggio, Italy) was diluted with iodized oil (Lipiodol Ultra Fluid; Guerbet; Aulnay-sous-Bois, France). Two 5 mL luer-lock syringes with a homogenous NBCA - Lipiodol combination were used for the injection. To improve the fluidity of the mixture and enable distal embolization, a high NBCA dilution of 1 : 8 was used. Effectiveness was observed (**Figure 2**). The procedure was declared successful when embolic ma-

Table 2. Summary Statistics of Clinical Parameters for patients with Benign prostate hyperplasia.

Name	Min	Max	Median	IQR
Age, years	54	90	73	17
MRI Prostate Volume, mL	50.12	83	68.798	13.003
IPSS score	18.04	35.886	24.685	5.286
Qmax, mL/s	2.4	9.95	7.25	2.299
PSA, ng/mL	4.2	9.867	6.917	1.625
QoL score	4	5.03	4.4	0.377
IIEF score	6.4	11.78	9.607	2.238

Abbreviations: IQR, Interquartile Range; MRI, Magnetic Resonance Imaging; IPSS, International Prostatic Symptoms Score; Qmax, maximum urinary flow rate; PSA, prostate-specific antigen; QoL, quality of life; IIEFS, International Index of Erectile Function score.

Table 3. Multivariable analysis of baseline characteristics.

Variables	Descriptive (mean ± S.D)
Age, years	72.6 ±10.5
Embolic: NBCA Glue	54 ± 49.1
Non-spherical PVA	56 ± 50.9
MRI Prostate Volume, mL	68.2 ± 8.39
IPSS score	25.3 ± 3.93
Qmax, mL/s	7.09 ± 1.75
PSA, ng/mL	6.95 ± 1.40
QoL, score	4.43 ± 0.25
IIEF, score	9.34 ± 1.41

Abbreviations: NBCA, N-butyl cyanoacrylate; PVA, polyvinyl alcohol; MRI, Magnetic Resonance Imaging; IPSS, International Prostatic Symptoms Score; Qmax, maximum urinary flow rate; PSA, prostate-specific antigen; QoL, quality of life; IIEFS, International Index of Erectile Function score.

terials embolized prostatic artery with complete stasis.

Evaluations

Data was gathered prior to PAE (baseline) and follow-up visits at three and six months following PAE. The IPSS questionnaire has been used to evaluate clinical symptoms. Scores on the IPSS questionnaire can range from 0 to 35 (scores of 7 indicate mild symptoms, 8 indicate moderate symptoms, and 20 indicate severe symptoms). The IPSS score change between the baseline and 6-month visit served as the primary endpoint. The International Index of Erectile Function form 5 (IIEF5, with scores ranging from "0, worst," to "25, best"), prostate volume was measured by magnetic resonance imaging and/or ultrasound were considered secondary endpoints.

Both clinical successes defined as QoL score < 3 and technical success defined as total occlusion of at least one vascularizing prostate artery were assessed. Minor problems were seen after PAE and examined in accordance with the quality improvement standards for percutaneous transcatheter embolization, but no substantial issues were observed in this investigation.

Statistical Analysis

Statistical analyses were performed using R 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria). We performed Shapiro-Wilk or Kolmogorov-Smirnov tests to assess the Normality assumption for each group within the independent variables. Independent measurement data were analyzed using two-way ANOVA, with factors A and B, followed by post-hoc pairwise comparisons using Tukey's test. Non-independent measurement data was processed using the Friedman M test, followed by post-hoc pairwise comparisons using the Conover-Iman test. The Bonferroni correction was used to adjust pairwise comparisons. For independent count data, if the theoretical frequency was between 1 and 5 and did not exceed 1 / 5, the R*C chi-square test was used for overall comparison, followed by pairwise comparisons using the adjusted standardized residuals test, but Fisher's exact test is generally recommended when the sample size is small, typically with expected cell counts below 5. Otherwise, the Fisher exact probability method was used for overall comparison, followed by pairwise comparisons using the adjusted standardized residuals test. Non-independent count data were compared using the paired chi-square test, followed by pairwise comparisons using the adjusted standardized residuals test. All tests with significance were accepted at $P \leq .05$.

RESULTS

Study population

A total of 125 consecutive patients were evaluated for eligibility, among them 11 falls under exclusion criteria, whereas 4 refused to participate, and the remaining 110 patients were treated with PAE. 54 patients were treated with NBCA glue, and the rest 56 patients underwent non-spherical PVA particles as shown in the flow chart (**Figure 3**).

Technical success

PAE was technically successful in all 110 patients (100%). We performed bilateral PAE in 109 patients (99%) and unilateral PAE in one patient because of unilateral agenesis or atherosclerotic occlusion of the prostatic artery. Patients characteristics range values are summarized in (**Table1**), min, max, median, and Interquartile Range (IQR) were shown in (**Table 2)**, the mean ± SD values of the baseline group are shown in (**Table 3)**.

The changes in values before and after PAE are shown in (**Table 4)**. In this table, the mean of prostate volume in baseline group was 67.1 ± 8.5, and after NBCA glue embolization, PV values significantly decreased after three and six months, their values were 56.1 ± 7.79 and 40.2 ± 5.4 respectively. On the other hand, by using the non-spherical PVA particles the MRI also showed PV to have significantly decreased values from baseline 68.2 ± 8.32 to 50.7 ± 7.48 and 38.8 ± 6.13 at three and six months respectively.

Clinical Success

The IPSS showed to have a decline in its score after usage of NBCA glue for PAE, as the mean values for the IPSS score in the baseline group before NBCA glue exposure 25.7 ± 4.3 while after NBCA glue, it was found to be 15.5 ± 2.3 and 7.2 ± 1.08 after three and six months respectively. Also, the same effect of non-spherical PVA particles was observed on the IPSS score as it showed that before exposure to non-spherical PVA particles, the IPSS score was 25.0 ± 3.5 which decreased after non-spherical PVA particles exposure with values 16.0 ± 2.40 and 7.24 ± 0.81 after three and

Table 4. Comparison of clinical responses at 3 time points between the two embolic agent groups.

	NBCA Glue				Non-spherical PVA			
Characteristics	**Baseline**	**3 months**	**6 months**	***p*-value**	**Baseline**	**3 months**	**6 months**	***P*-value**
PV, mL	67.7 ± 8.5	56.7 ± 7.9	40.2 ± 5.4	< .0001	68.2 ± 8.3	50.7 ± 7.4	38.8 ± 6.1	< .0001
IPSS	25.7 ± 4.3	15.5 ± 2.3	7.2 ± 1.09	< .0001	25.0 ± 3.5	16.0 ± 2.4	7.2 ± 0.81	< .0001
Q max, mL\s	8.6 ± 2.3	8.6 ± 2.3	15.4 ± 2.3	< .0001	7.19 ± 1.6	8.40 ± 1.9	15.1 ± 2.4	< .0001
QoL score	4.43 ± 0.2	2.3 ± .4	1.5 ± 2.27	< .0001	4.43 ± 0.2	2.38 ± .4	1.56 ± 0.55	< .0001
IIEF score	9.4 ± 1.5	14.5 ± 1.1	19.3 ± 1.3	< .0001	9.22 ± 1.3	14.7 ± .9	19.5 ± 0.96	< .0001

Abbreviations: PV, prostate volume; IPSS, International Prostatic Symptoms Score; Qmax, maximum urinary flow rate; QoL, quality of life; IIEFS, International Index of Erectile Function score.

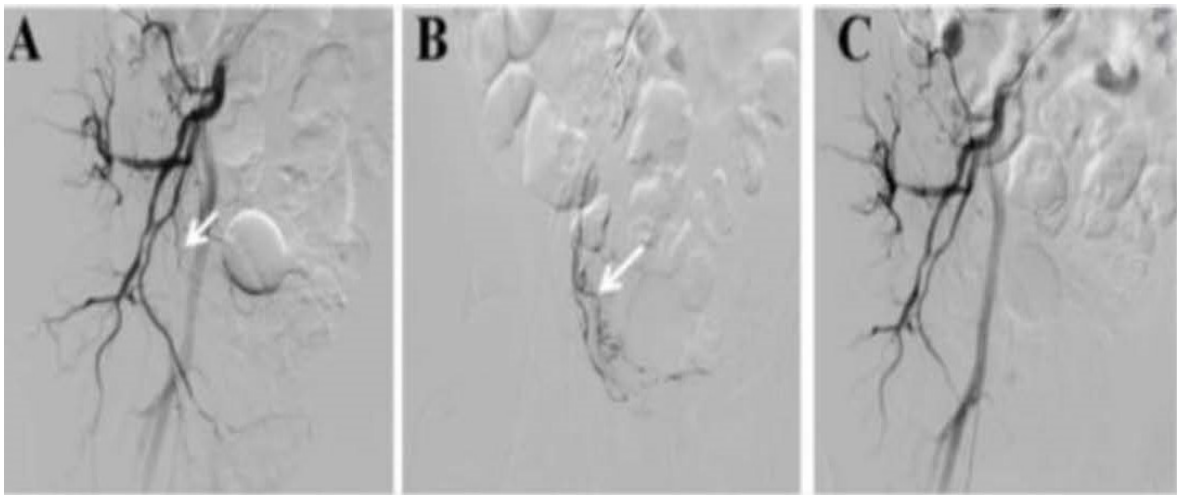

Figure 1. Arteriographic images of 77-year-old patient with lower urinary tract symptoms associated with benign prostatic hyperplasia who underwent bilateral prostatic artery embolization. **(A)** Selective catheterization demonstrating the prostate gland before embolization. **(B)** Prostatic artery angiogram after embolization using non-spherical PVA. Using 250 - 355 µm non-spherical PVA particles.

six months respectively.

The Qmax showed significant improvement, the mean Qmax value was 8.6 ± 2.3 at baseline group and after using NBCA glue, it was 8.6 ± 2.3 at three months and 15.4 ± 2.3 at six months. The same improvement was found after non-spherical PVA particles, the values of Qmax was at baseline 7.19 ± 1.67, and after injecting non-spherical PVA particles it was 8.40 ± 1.98, 15.1 ± 2.42 after three and six months respectively.

In addition, the mean values for QoL score improved for patients who received NBCA glue from baseline 4.43 ± .27 to 2.30 ± 0.36 and to 1.58 ± 2.27 after three and six months respectively. The same improvement was found after using non-spherical PVA particles for embolization, as QoL scores were improved from 4.43± 0.24 as baseline to 2.38 ± .40 and 1.56 ± 0.55 after three and six months.

Finally, the IIEFS mean values significantly increased after using both NBCA glue and non-spherical PVA particles, the values that were found were 9.46 ± 1.51 as baseline, then 14.5 ± 1.07 and 19.3± 1.33 after three and six months respectively post NBCA glue, also the IIEFS values post non-spherical PVA particles used were 14.7 ± .96 and 19.5 ± .96 after three months and six months and baseline was 9.22 ± 1.30.

Then, we want to investigate whether or not this short-term treatment can induce a significantly greater increase in clinical observation through measurement over time. The result analysis showed that the prostate volume decreased considerably after patients received non-spherical PVA particles when compared with patients who received NBCA glue (**Figure 2A**). While other characteristics, such as IPSS, Qmax, QoL, and IIEFS values had no significant changes after using NBCA glue and nonspherical PVA particles (**Figure 2 B - E**). No major complications were noted in this study, there was a minor complication with mild penile pain in three patients which disappeared spontaneously the day after the symptom occurred without the need for further treatment.

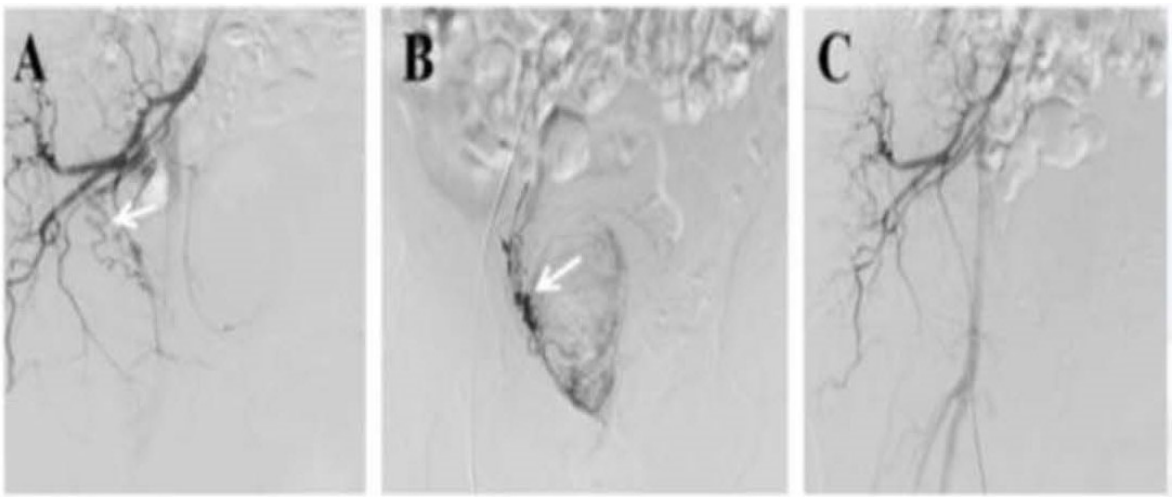

Figure 2. Example of prostate artery embolization (PAE) with N-butyl cyanoacrylate glue in a 81-year-old patient with symptomatic benign prostatic hyperplasia. **(A)** Left prostatic artery angiogram before PAE showing enhancement of the left prostatic lobe. **(B)** Follow-up angiogram after PAE with a mixture of Glubran®2/Lipiodol in a 1:8 ratio showing total occlusion.

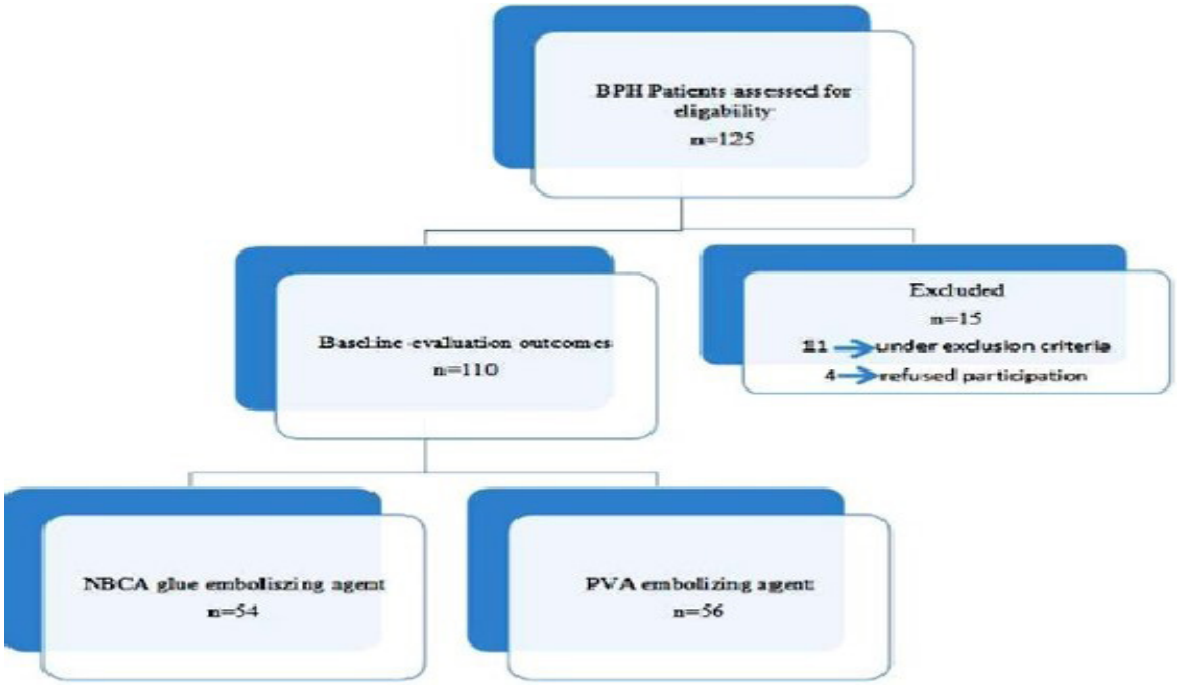

Figure 3. Flow chart of the study design.

DISCUSSION

The introduction of PAE to relieve from LUTS and decrease the gland volume without surgery is a major breakthrough. DeMeritt et al.[15] reported prostatic volume reduction and improvement of LUTS after treatment of prostatic hemorrhage with PAE. While Carnevale et al.[16] reported the first instance of PAE, especially for the treatment of BPH in two patients who had volume reductions of 47.8 % and 27.8 %. The following research revealed a range of mean prostatic volume reductions, ranging from 18% to 32 %[3].

Bagla et al.[17] reported early results from a U.S. trial of PAE in 2014. Bilateral PAE was successful in 18 of

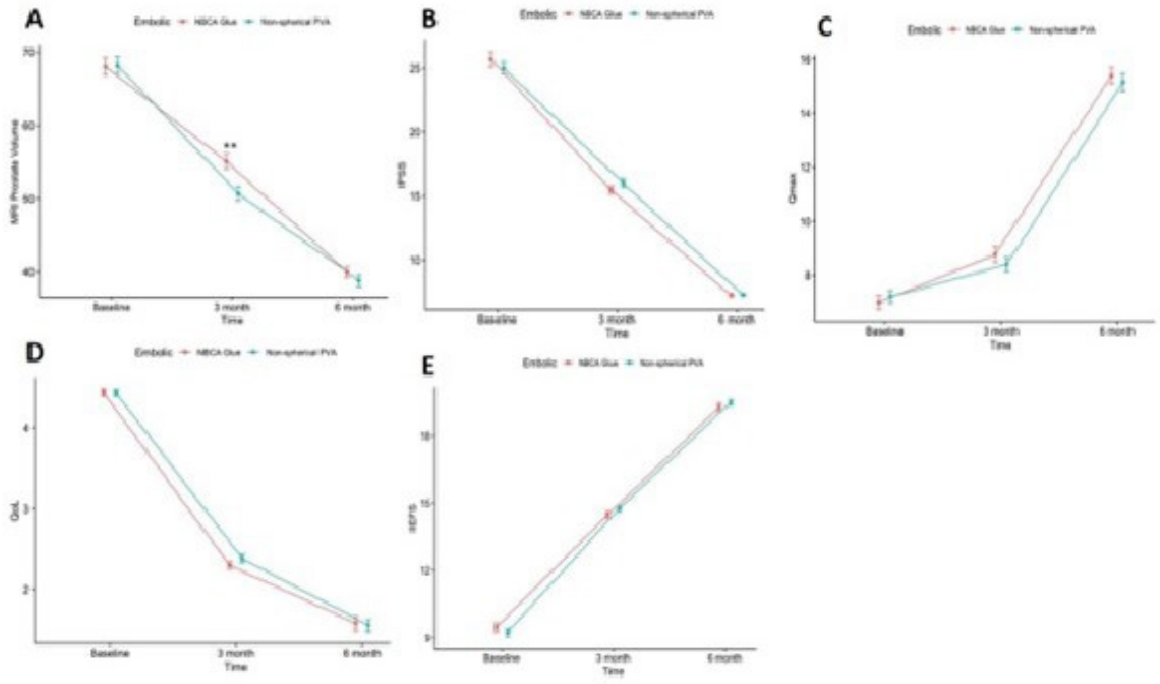

Figure 4. Difference of embolic agent: **(A)** MRI difference before and after NBCA glue and non-spherical PVA embolic agents treatments, **(B)** IPSS difference before and after NBCA glue and non-spherical PVA embolic agents treatments, **(C)** Qmaxdifference before and after NBCA glue and non-spherical PVA embolic agents treatments,**(D)** QoL difference before and after NBCA glue and non-spherical PVA embolic agents treatments, **(E)** IIEFS difference before and after NBCA glue and non-spherical PVA embolic agents treatments.

19 patients in their cohort without any complications. Clinical success was found in 19 of 20 patients with significant improvement of IPSS and QoL. PV was decreased by 18% at 6 months. In our study, there was a significant decrease in total prostatic volume, IPSS, and QoL values by using non-spherical PVA particles and NBCA glue after 3 and 6 months follow up and it was found that the prostatic volume had a much more reduction after 6 month of treatment compared with the baseline values. On the other hand, the mean for Qmax and IIEFS significantly increased after patients received non-spherical PVA and NBCA glue compared with baseline values after 6 months of treatment.

Yet, It is unknown what kind of embolic agent is best. Non-spherical PVA particles were utilized in animal experimental research confirming the effectiveness and safety of PAE[3]. The utilization of non-spherical PVA particles with a diameter of 250 – 355 μm has been proven in further research[18]. Although Jeon et al.[9] claimed that non-spherical PVA particles may have superior effects in PAE with deeper penetration into the periphery, anastomosis between the prostatic arteries and nearby arteries raises concerns for non-target embolization[19].

Using appropriate embolizing agents such as non-spherical PVA particles through PErFecTED technique has promising results, as acclaimed by Carnevale et al.[8] in 2014, overall immediate technical success of PAE was 100 %, and PErFecTED technique was feasible in 68 % of patients. There were significant improvements in IPSS, QoL, Qmax, and PV compared with baseline values. There were no major complications. The same we have observed in our study, there was a significant decrease in total prostatic volume, IPSS, and QoL values by using non-spherical PVA particles as well as the mean for Qmax and IIEFS significantly increased.

NBCA has several benefits, yet a significant number of interventional radiologists are reluctant to use it, due to a lack of skill and steep learning to use glue for peripheral endovascular applications like PAE. The major benefit of NBCA is the quicker procedure compared to particle embolization, which cuts down on the amount of time needed for fluoroscopy and, thus, the radiation exposure to the patient. In our investigation, the entire combination injection time was less than 40s, and the whole fluoroscopy time was under 30 min. A further benefit of NBCA is the quick polymerization from surface to core, which prevents the opening of pre-existing vascular anastomosis, an occurrence reported with particles, and may reduce the risk of non-target embolization[18]. Furthermore, because polymerization upon interaction with blood anions is independent of coagulation function, NBCA may be more effective than other embolic agents in patients with coagulopathy[21]. Additionally, a greater chance of adverse events is linked to smaller embolic particle size[15]. Other benefits of NBCA / Lipiodol are numerous. Compared to other embolic materials that cannot be seen directly, including microparticles, lipiodol renders the embolic substance radiopaque, facilitating fluoroscopy guidance. Additionally, the prostate gland absorbs the lipiodol, which makes the distribution of the treated prostatic areas and seen well in MRI. According to research on the usage of NBCA on liver, this distribution might be considered as marker for clinical effectiveness[22]. It is to be noted that Glubran 2 has the benefit of being cost–effective in many countries even though it is mixed with lipiodol, yet it is not more expensive than using microparticles. After NBCA glue embolization, the possibility of Ischemic consequences has been of great concern. However, our findings indicate that when compared to other widely used embolic agents such microparticles, NBCA and Lipiodol may not result in a larger number of ischemic consequences. The characteristics of NBCA explain this observation[23]. The ratio of NBCA/Lipiodol needs to be modified accurately on how long the segment needs to be embolized. This adjustment maintains enough viscosity to prevent excessive distal penetration into the capillary bed while still providing enough fluidity to ensure distal embolization of the feeding artery, maintaining circulation in the distal post embolic tissue via collateral channels in the intramural microcirculation[23]. In order to reduce the risk of complications, precautions must be taken. Important steps include flushing the microcatheter to eliminate any ionic solutions before the injection and quickly retracting the catheter thereafter to prevent NBCA from becoming trapped and adhering to the vessel[15]. To our knowledge, no studies have compared non-spherical PVA particles in PAE with NBCA glue. According to (**Table 4**), the non-spherical PVA particle results were better than the NBCA glue group in terms of clinical outcomes assessed by subjective (IPSS and QoL) and objective values (prostatic volume). Statistical significance was attained for the volume decrease of the prostate gland. Although, It is thought that non-spherical PVA particles are more likely than NBCA glue in terms of a significant drop in the volume of the prostate gland, which led to the achievement of statistical significance[11].

Prostatic arteries have extremely diverse origins and modest sizes of less than 2 mm. To prevent embolization failure and non-target embolization of the rectum, bladder, and penis, it is necessary to have a thorough grasp of the prostatic artery architecture. Though open prostatectomy is the procedure of choice for BPH larger than 80 cm3. Recently, several reports have suggested that PAE for prostate volume greater than 80 cm3 is safe and effective[2]. These reports reflect the growing interest in PAE, especially in patients who are not candidates for open surgery, TURP, or minimally invasive surgery.

Our study has some limitations. First, our sample size is just 110 patients may have hindered our capacity to identify significant changes and may account for some inconsistencies with other research. Second, there may be a chance of bias because PAE was carried out by a senior interventional radiologist with his own extensive experience with PAE using NBCA glue and non-spherical PVA particles. Third, a short follow-up time of 3 and 6 months was not enough to help interventionalist to choose the appropriate embolic agent. We aimed to present the first clinical data on PAE comparing two distinct embolic agents, i.e. NBCA glue and non-spherical PVA to treat LUTSs associated with BPH to the best of our knowledge. Therefore, it is necessary for further research with longer follow-up period to compare embolic agents.

CONCLUSIONS

PAE treatment with NBCA glue or non-spherical PVA particles is safe, and effective for individuals suffering from LUTS caused by BPH. This gives the physicians

option to select between embolizing agents based on the patient's clinical status and the architecture of the prostatic artery.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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REFERENCES

1. Aslan G, Aslan D, Kizilyar A, Ispahi C, Esen A. A prospective analysis of sexual functions during pregnancy. Int J Impot Res. 2005;17:154-7.
2. McVary KT, Roehrborn CG, Avins AL, et al. Update on AUA guideline on the management of benign prostatic hyperplasia. J Urol. 2011;185:1793-1803.
3. Roehrborn CG, Andriole GL, Wilson TH, et al. Patient-reported outcomes after 4 years of treatment with dutasteride plus tamsulosin or either monotherapy in men with benign prostatic hyperplasia. Urology. 2009;73:1363-1368.
4. Madersbacher S, Alivizatos G, Nordling J, Sanz C, Emberton M, de la Rosette J. J. M. C. H. EAU 2004 guidelines on assessment, therapy and follow-up of men with lower urinary tract symptoms suggestive of benign prostatic obstruction (BPH guidelines). Eur Urol. 2004;46:547–554.
5. Oelke M, Bachmann A, Descazeaud A, et al; European Association of Urology. EAU guidelines on the treatment and follow-up of nonneurogenic male lower urinary tract symptoms including benign prostatic obstruction. Eur Urol. 2013;64:118–140.
6. Bagla S, Martin CP, Van Breda A, et al. Early results from a United States trial of prostatic artery embolization in the treatment of benign prostatic hyperplasia. J Vasc Interv Radiol. 2014;25:47–52.
7. McVary KT, Roehrborn CG, Avins AL, et al. Update on AUA guideline on the management of benign prostatic hyperplasia. J Urol. 2011;185:1793–1803.
8. Lourenco T, Pickard R, Vale L, et al. Minimally invasive treatments for benign prostatic enlargement: systematic review of randomized controlled trials. BMJ. 2008;337:966–969.
9. Li Q, Duan F, Wang MQ, et al. Prostatic arterial embolization with small-sized particles for the treatment of lower urinary tract symptoms due to large benign prostatic hyperplasia: preliminary results. Chin Med J (Engl). 2015;128:2072-2077.
10. Gravas S, Cornu JN, Gacci M, Gratzke C, Herrmann TRW, Mamoulakis C, et al. Management of non-neurogenic male LUTS. EAU Guidelines Edn presented at the EAU Annual Congress Amsterdam 2020.
11. Geevarghese R, Harding J, Parsons N, Hutchinson C, Parsons C. The relationship of embolic particle size to patient outcomes in prostate artery embolization for benign prostatic hyperplasia: A systematic review and meta-regression. Clin Radiol. 2020;75:366–374.
12. Abdulmalak G, Chevallier O, Falvo N, Di Marco L, Bertaut A, Moulin B, et al. Safety and efficacy of transcatheter embolization with Glubran®2 cyanoacrylate glue for acute arterial bleeding: A single-center experience with 104 patients. Abdom Radiol. 2018;43:723–733.
13. Loffroy R, Desmyttere AS, Mouillot T, Pellegrinelli J, Facy O, Drouillard A, et al. Ten-year experience with arterial embolization for peptic ulcer bleeding: N-butyl cyanoacrylate glue versus other embolic agents. Eur Radiol. 2021;31:3015–3026.
14. Dadas B, Alkan S, Cifci M, Basak T. Treatment of tripod fracture of zygomatic bone by n-2-butyl cyanoacrylate glue fixation and its effects on the tissues. Eur Arch Otorhinolaryngol. 2007;264:539–544.
15. Loffroy R, Mouillot T, Bardou M, Chevallier O. Current role of cyanoacrylate glue transcatheter embolization in the treatment of acute nonvariceal gastrointestinal bleeding. Expert Rev Gastroenterol Hepatol. 2020;14:975–984.
16. Carnevale FC, Antunes AA, Da Motta JM, Leal Filho et al. Prostatic artery embolization as a primary treatment for benign prostatic hyperplasia: Preliminary results in two patients. Cardiovasc Intervent Radiol. 2010;33:355–361.
17. Jeon GS, Won JH, Lee BM, et al. The Effect of Transarterial Prostate Embolization in Hormone-induced Benign Prostatic Hyperplasia in Dogs: A Pilot Study. J Vasc Interv Radiol. 2009;20:384–390.
18. Pisco JM, Rio Tinto H, Campos Pinheiro L, et al. Embolization of prostatic arteries as treatment of moderate to severe lower urinary symptoms (LUTS) secondary to benign hyperplasia: Results of short- and mid-term follow-up. Eur Radiol. 2013;23:2561–2572.
19. Wang MQ, Guo LP, Zhang GD, et al. Prostatic arterial embolization for the treatment of lower urinary tract symptoms due to large (>80 mL) benign prostatic hyperplasia: results of midterm follow-up from Chinese population. BMC Urol. 2015;15:33.
20. Li YJ, Barthes-Biesel D, Salsac AV. Polymerization kinetics of n-butyl cyanoacrylate glues used for vascular embolization. J Mech Behav Biomed Mater. 2017;69:307–317.
21. Malling B, Røder MA, Brasso K, Forman J, Taudorf M, Lönn L. Prostate artery embolisation for benign prostatic hyperplasia: A systematic review and meta-analysis. Eur Radiol. 2019;29:287–298.
22. Shuster A, Gunnarsson T, Klurfan P, Larrazabal R. N-butyl cyanoacrylate proved beneficial to avoid a nontarget

embolization of the ophthalmic artery in endovascular management of epistaxis. A neurointerventional report and literature review. Interv Neuroradiol. 2011;17:17–21.

23. Jae HJ, Chung JW, Kim HC, So YH, Lim HG, Lee W, Kim BK, Park JH. Experimental study on acute ischemic small bowel changes induced by superselective embolization of superior mesenteric artery branches with N-butyl cyanoacrylate. J Vasc Interv Radiol. 2008;19:755–763.