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In-hospital cost analysis of prostatic artery embolization compared with transurethral resection of the prostate: *post hoc* analysis of a randomized controlled trial

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Objectives

To perform a *post hoc* analysis of in-hospital costs incurred in a randomized controlled trial comparing prostatic artery embolization (PAE) and transurethral resection of the prostate (TURP).

Patients and Methods

In-hospital costs arising from PAE and TURP were calculated using detailed expenditure reports provided by the hospital accounts department. Total costs, including those arising from surgical and interventional procedures, consumables, personnel and accommodation, were analysed for all of the study participants and compared between PAE and TURP using descriptive analysis and two-sided *t*-tests, adjusted for unequal variance within groups (Welch *t*-test).

Results

The mean total costs per patient (±SD) were higher for TURP, at €9137 ± 3301, than for PAE, at €8185 ± 1630. The mean difference of €952 was not statistically significant (P = 0.07). While the mean procedural costs were significantly higher for PAE (mean difference €623 [P = 0.009]), costs apart from the procedure were significantly lower for PAE, with a mean difference of €1627 (P < 0.001). Procedural costs of €1433 ± 552 for TURP were mainly incurred by anaesthesia, whereas €2590 ± 628 for medical supplies were the main cost factor for PAE.

Conclusions

Since in-hospital costs are similar but PAE and TURP have different efficacy and safety profiles, the patient's clinical condition and expectations – rather than finances – should be taken into account when deciding between PAE and TURP.

Keywords

prostatic artery embolization, transurethral resection of the prostate, benign prostatic hyperplasia, prostate, obstruction, costs, #PAE, #TURP, #UroBPH

Introduction

Approximately 50% of men aged 50–60 years and ~90% of men aged ≥85 years are affected by BPH [1]. Treatment costs of LUTS secondary to BPH (BPH-LUTS) are a substantial economic burden that will increase in the future as a result of demographic changes; thus, the estimated annual treatment costs were US$ 4 bn in the USA in 2006, and €858 per patient in Europe in 2003 [2,3].

The 'gold standard' treatment for most patients is TURP if conservative and medical treatment fail [4]. Although TURP is performed in > 100 000 men annually in the USA [5], it is associated with a high morbidity [6,7], 40% of patients have residual LUTS requiring drug treatment within 5 years of surgery [8], and an endourological reintervention rate of 12.3% at 8 years has been reported [9]. These drawbacks have led to a continuous search for less invasive alternative treatment options.

Prostatic artery embolization (PAE) is a minimally invasive endovascular procedure performed under local anaesthesia and was shown to improve BPH-LUTS for the first time in 2000 [10]. The improvement in BPH-LUTS after PAE is similar to that achieved by TURP and it is associated with fewer adverse events [11–14]. PAE was therefore recently recommended as a minimally invasive treatment alternative for BPH-LUTS by the National Institute for Health and Care

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Excellence (NICE) [15]. Desobstructive efficacy with PAE is, however, inferior to that associated with TURP [13], and no long-term findings have so far been published. Although recent urological guidelines still do not yet recommend PAE outside controlled studies [4,16], it is increasingly being performed worldwide.

Considering the high economic burden of BPH-LUTS treatment and the substantial differences between technical aspects of PAE and established transurethral surgical treatments, cost analyses in this field seem to be of particular interest. Only one cost analysis is available for PAE so far: Bagla et al. [17] retrospectively compared costs of patients undergoing PAE or TURP in a hospital setting in the USA and found statistically significantly lower costs for PAE.

Treatment costs strongly depend on the performance setting and may also vary among different healthcare systems, regions, and institutions. The aim of the present study, therefore, was to analyse costs that occurred in a randomized controlled trial comparing the efficacy and safety of PAE and TURP in Switzerland [13].

Patients and Methods

Study Design

Data were derived from an unblinded, single-centre, randomized, controlled trial [13]. The study including the present *post hoc* analysis was approved by the local ethics committee (EKSG14/004) and was funded by a grant from the hospital's research committee (14/08). Study coordination, data management, and data and safety monitoring were performed by independent experts from the hospital's Clinical Trials Unit. The trial was performed according to the World Medical Association Declaration of Helsinki [18] and the Guidelines for Good Clinical Practice [19] and was registered at ClinicalTrials.gov (NCT02054013). The Clinical Trials Unit statistician (S.G.) performed the data analyses.

Participants

Inclusion criteria were as follows: age > 40 years; TURP indication; patient refractory to medical therapy or not willing to undergo or continue medical treatment; prostate size 25–80 mL, measured by transabdominal ultrasonography; IPSS $\geq$ 8; IPSS quality of life $\geq$ 3; maximum urinary flow rate < 12 mL/s and/or urinary retention; and written informed consent [13].

Exclusion criteria were as follows: severe atherosclerosis, aneurysmatic changes or severe tortuosity in the aortic bifurcation or internal iliac arteries; acontractile detrusor; neurogenic lower urinary tract dysfunction; urethral stenosis; bladder diverticulum; bladder stone; allergy to intravenous contrast media; contraindication for MRI; pre-interventionally proven carcinoma of the prostate; and renal failure (GFR < 60 mL/min) [13].

Interventions

The PAE procedures were performed by one experienced interventional radiologist familiar with the procedure according to established techniques [12,20]. After insertion of a 16-F transurethral catheter, a unilateral femoral sheath was placed in the right common femoral artery under local anaesthesia. Prostatic arterial supply was identified by selective internal iliac arteriography with a 5-F angiocatheter (Merit Medical Inc., South Jordan, UT, USA). Catheterization of prostatic arteries was performed with 1.9–2.4-F microcatheters (Parkway soft [Asahi Intecc, Nagoya, Japan]; Progreat [Terumo, Tokyo, Japan]; and Direxion [Boston Scientific, Natick, MA, USA]). Embozene® microspheres (Boston Scientific) were used for embolization. In patients with visible arterial collaterals to extraprostatic territories and without the possibility of occlusion with microcoils, 400-μm microspheres were used. All other patients were embolized using 250-μm particles. The microspheres, which are delivered in 20-mL syringes containing 2 mL of microspheres and 5 mL of NaCl, were diluted with 2.5 or 3 mL of Visipaque 320 (GE Healthcare, Little Chalfont, UK) according to the manufacturer's instructions. Cone-beam CT was applied only in difficult cases to identify prostatic arteries or prevent off-target embolization [21]. PAE was performed bilaterally if possible. Successful embolization was defined as absence of the normal blush of the prostate and complete stasis of flow in the prostatic arteries on post-embolization angiography. The transurethral catheter was removed on the morning after the intervention in patients without indwelling catheter before hospitalization. All patients received peri-operative antibiotic prophylaxis for 24 h (ciprofloxacin 500 mg twice daily).

Monopolar TURP was performed under spinal or general anaesthesia by four board-certified study physicians using a 24-F resectoscope (Karl Storz Endoskope, Binningen, Switzerland) with a standard tungsten wire loop (Karl Storz Endoskope) and electrolyte-free mannitol-sorbitol solution (Purisole [Fresenius Kabi AG, Bad Homburg, Germany]). A 20-F three-way catheter was inserted for irrigation after resection and left for at least 2 days, depending on postoperative haematuria. Patients received peri-operative antibiotic prophylaxis (ciprofloxacin 500 mg twice daily), which was discontinued after removal of the bladder catheter or after 3 days at the latest.

According to the study protocol, the earliest patient discharge after both procedures was to be on the second postoperative day.

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Financial Data

Detailed expense reports based on work records of activities and services performed by the medical and nursing staff, medical consumables used, medications administered, and costs for accommodation, rooms and equipment were provided by the accounts department of the hospital for each of the study participants. These were used to compare in-hospital costs arising from PAE and TURP. The calculations of the costs of the interventional and surgical facilities (i.e. technical staff, premises and equipment) were based on average personnel costs per min, fixed charges for room costs, and proportionate depreciation of equipment. For PAE, the costs for operation facilities also included the costs of the imaging studies (e.g. angiography, cone-beam CT) because they could not be filtered out separately. Fixed charges were also applied for the calculation of administrative costs.

Costs were divided into procedural costs and costs arising from the hospital stay.

Procedural costs for TURP included professional charges of the urologist, costs of operation facilities (i.e. technical staff, premises and equipment), medical supplies required for TURP (e.g. resection loop, irrigation solution, tissue evacuation system), costs for anaesthesia (i.e. anaesthesiology staff and medical supplies, recovery room) and histological tissue examination.

Procedural costs of PAE included professional charges of the interventional radiologist, costs of operation facilities (i.e. technical staff, premises, equipment and imaging studies) and medical supplies required for PAE (e.g. local anaesthesia, access sheath, microcatheters, guidewires, microspheres).

Costs of the inpatient stay in both groups included physician's professional charges, services by nursing specialists, medical supplies (e.g. irrigation solutions, wound care), medication, laboratory services, administration and accommodation (i.e. premises, housekeeping and catering). The latter was based on fixed sums calculated by the accounts department.

Expense reports were provided in Swiss francs and converted to Euros (€) as a more widely used currency based on the average exchange rate over the study recruitment period from 2014 to 2017 of €1 = 1.12 Swiss francs.

Statistics

Cost breakdowns were summarized using means and standard deviations. Differences between PAE and TURP were tested using two-sided *t*-tests, adjusted for unequal variance within groups (Welch *t*-test). *P* values for recovery variables were also calculated using two-sided *t*-tests and those for adverse events using Fisher's exact test.

Ethics Statement

Informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Results

A total of 103 patients were randomly assigned to PAE or TURP between February 2014 and May 2017. Of these, 48 patients underwent PAE and 51 TURP. The data for one patient who underwent PAE could not be provided by the accounts department because of incorrect allocation by the software. The patient's hospital stay was uneventful. Baseline characteristics of the study patients and details of how PAE and TURP were performed are reported in detail elsewhere [13] and are summarized in Table 1.

Costs for PAE and TURP are categorized in Table 2 and illustrated in Fig. 1. The mean ± SD total costs per patient were lower for PAE (€8185 ± 1630) than for TURP (€9137 ± 3301); however, the mean difference of €952 was not significant ($P = 0.07$).

The mean ± SD costs for the surgical procedure alone were €4240 ± 774 for PAE and €3617 ± 1429 for TURP (mean difference €623; $P = 0.009$). While the main cost factor for the surgical procedure was anaesthesia (mean costs €1433 ± 552) for TURP, medical supplies were the major costs for PAE (mean costs €2590 ± 628).

Mean costs of the inpatient stay were €3837 ± 1179 for PAE and €5405 ± 2280 for TURP (mean difference €1627; $P \leq 0.001$). Services provided by the nursing staff were one of the main cost factors for the hospital stay for both PAE (€1265 ± 369) and TURP (€2143 ± 884).

Discussion

This *post hoc* analysis shows that total in-hospital costs tend to be higher for TURP than for PAE; however, the difference between mean total costs was small, at 10.4%, and not statistically significant.

Separate analysis of the costs of the surgical procedure and inpatient costs showed that the costs of surgery were statistically significantly higher for PAE, while those for the inpatient stay were statistically significantly higher for TURP. Substantial differences were found when the costs for the surgical procedure were analysed in more detail. Clear savings were found for PAE, as no general or spinal anaesthesia and no recovery room were required. In contrast, the procedural costs for PAE were high, especially for medical supplies, the use of expensive imaging studies, and a longer intervention time.

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Table 1 Baseline characteristics, peri-operative data, and recovery variables of the study patients.

	PAE (*N* = 48)	TURP (*N* = 51)	*P*
Baseline characteristics, mean ± SD			
Age, years	65.7 ± 9.3	66.1 ± 9.8	
Body mass index*	26.5 ± 4.2	27.0 ± 3.9	
Charlson Comorbidity Index	3.6 ± 1.6	4.3 ± 2.1	
PSA, ng/mL	4.2 ± 5.4	4.5 ± 5.6	
Prostate volume (MRI), mL	52.8 ± 32.0	56.5 ± 31.1	
Peri-operative data			
Anesthesia, *n* (%)			
General	–	26 (51)	
Spinal	–	25 (49)	
Local	48 (100)	–	
Mean ± SD procedure time, min	122.2 ± 25.8	69.5 ± 22.5	<0.001
PAE details			
Bilateral, *n* (%)	36 (75.0)	–	
Unilateral, *n* (%)	12 (25.0)		
Mean ± SD fluoroscopy time, min	50.8 ± 17.5	–	
Mean ± SD radiation dose, Gy/cm^2	176.5 ± 101.2	–	
Use of cone beam CT, *n* (%)	5 (10.4)	–	
Mean ± SD pain during intervention (visual analogue scale)	0.1 ± 0.6	–	
Additional analgesics necessary[†], *n* (%)	2 (4.2)	–	
Mean ± SD amount of embolization particles used, mL	1.0 ± 0.4	–	
TURP details			
Mean ± SD time of resection, min	–	58.25 ± 24.33	
Mean ± SD weight of resected tissue, g	–	25.20 ± 15.16	
Recovery variables			
Mean ± SD haemoglobin decrease 24 h, g/dL	−4.3 ± 7.0	−13.8 ± 11.0	0.001
Mean ± SD bladder catheter indwelling time, days	1.3 ± 1.4	3.3 ± 1.4	0.001
Mean ± SD duration of hospital stay, days	2.2 ± 0.6	4.2 ± 1.7	0.001
Adverse events during hospitalization, *n* (%)			
Clavien Grade I	8 (16.7)	5 (9.8)	0.38
Clavien Grade II	0 (0)	1 (2)[§]	1.00
Clavien Grade IIIb	0 (0)	1 (2)[¶]	1.00

*All differences in baseline characteristics between groups were nonsignificant; P values for recovery variables are from two-sided t-tests and those for adverse events from Fisher's exact test. *Body mass index is the weight in kg divided by the square of the height in meters. [†]Paracetamol 1 g was given before surgery. [§]UTI. [¶]Postoperative haemorrhage associated with surgery.*

Table 2 Cost breakdown for in-hospital costs arising from prostatic artery embolization and TURP.

Expense item	Mean costs per patient ± SD (€)		*P*
	PAE (*n* = 47)*	TURP (*n* = 51)	
Surgical procedure (total)	**4240 ± 774**	**3617 ± 1429**	**0.009**
Physician professional charges	646 ± 460	538 ± 504	0.28
Operation facilities (technical staff, premises, equipment; for PAE: imaging studies)	1005 ± 72	545 ± 280	<0.001
Medical supplies	2590 ± 628	717 ± 367	<0.001
Anaesthesia (anaesthesiology staff, medical supplies needed for anaesthesia, recovery room)	0	1433 ± 552	–
Pathology	0	359 ± 273	–
Inpatient stay (total)	**3837 ± 1179**	**5405 ± 2280**	**<0.001**
Physician professional charges	1415 ± 795	1806 ± 1043	0.04
Services by nursing specialists	1265 ± 369	2143 ± 884	<0.001
Medical supplies	68 ± 10	120 ± 59	<0.001
Medication	275 ± 39	147 ± 62	<0.001
Accommodation (including housekeeping and catering)	528 ± 204	813 ± 368	<0.001
Laboratory services	288 ± 130	375 ± 168	0.005
Administrative costs	108 ± 58	167 ± 158	0.01
Total in-hospital costs	8185 ±1630	9137 ± 3301	0.07

*PAE, prostatic artery embolization. Costs are reported in Euros and values reported are means ± SD; P values from two-sided t-tests. *Data from one patient who underwent PAE could not be provided by the accounts department.*

Statistically significantly higher inpatient costs were found for TURP. As TURP is clearly more invasive than PAE, a higher degree of postoperative care, including nursing and physician services, seems to be plausible. Moreover, patients had a statistically significantly longer hospital stay after TURP.

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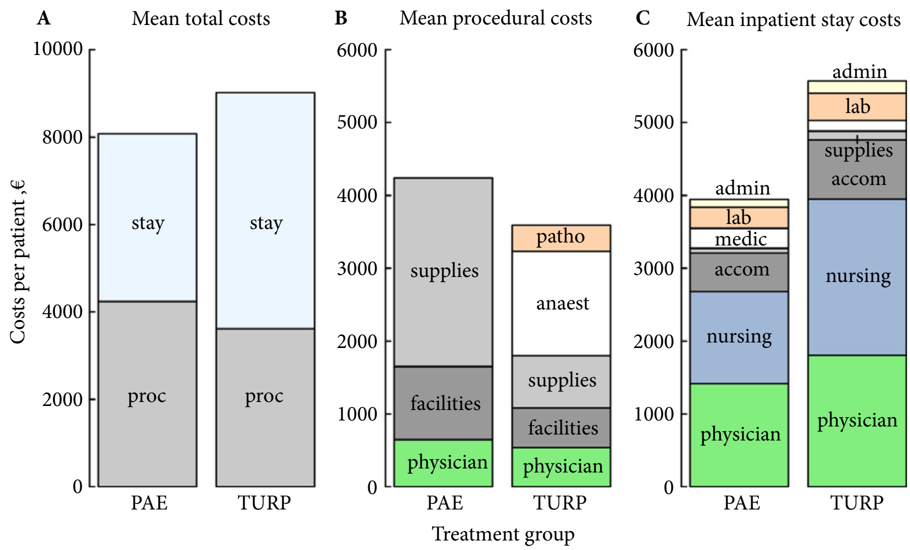
Fig. 1 Cost summary for prostatic artery embolization (PAE) and TURP, grouped by mean total (**A**), procedural (**B**), and inpatient stay (**C**) costs. stay, inpatient stay; proc, surgical procedure; suppl, medical supplies; facil, operation facilities; phys, physician professional charges; anaest, anaesthesia; patho, pathology; lab, laboratory services; medic, medication; accom, accommodation; nurs, services by nursing specialists; admin, administrative costs.



The randomized study design is the main strength of the present study. As PAE and TURP have a clearly different safety and efficacy profile, selection bias would have been likely to occur in a non-randomized study setting. All financial data used in this analysis were routinely and independently assessed by the hospital accounts department.

Nevertheless, this study was performed as a *post hoc* analysis and therefore has the typical limitations of such studies. Patient characteristics and technical variations in PAE and TURP were limited as a result of clear definitions by the study protocol. To assess potential complications, the study protocol also defined the minimum hospital stay after surgery, which is an important cost factor. PAE can also be performed in an outpatient setting, leaving room for considerably lower costs than inpatient treatment; however, considering the frequent occurrence of pain in the first 24 h after PAE [13], also reflected by the more frequent use of analgesics in patients who underwent PAE in the present study, a short-term hospital stay seems to be justified. In addition, the duration of hospitalization can also be reduced after TURP, as shown elsewhere [22,23]. PAE was performed by a specific interventional radiologist and TURP by selected surgeons, which may give rise to expert bias.

Some of the costs included, for example, premises and depreciation of equipment, can only be estimated. The fixed sums used for the calculations are based on standard calculations used by the hospital accounts department. Costs that arose from in-hospital complications (Table 1) could not be filtered out separately by the accounts department of the hospital and, therefore, were not available for the present analysis. As healthcare systems vary widely among countries, our results are not generalizable to countries with clearly different healthcare structures.

So far, only one comparative cost analysis has been made available for PAE. Although Bagla et al. [17] performed a non-randomized comparison of in-hospital costs for PAE and TURP, with statistically significantly different baseline characteristics between the two groups, most of their results were in line with the present findings; thus, the authors report on lower total costs, and a shorter duration of hospitalization, but higher costs for the intraprocedural supplies for PAE. Differences between that and the present study regarding the total amounts might be caused mainly by the different assessment and classification of costs, different materials used for surgery, and shorter hospitalization times.

The present study focused on in-hospital costs. Postoperative incapacity for work, management of post-hospitalization adverse events, and re-interventions and medical treatment for BPH-LUTS during long-term follow-up would have to be included to estimate the actual economic burden for the healthcare system. Such data are not available yet, but will be assessed during the long-term follow-up of the trial. Because of its efficacy and safety profile, PAE has been suggested as an appropriate alternative to medical treatment [13,24]. In Switzerland, costs of €202.05 and €456.25 per year arise from prescription of the cheapest α-blocker and a combined α-blocker and 5-α-reductase inhibitor [25]. Considering mean total and surgical procedure costs for PAE of €8185 ± 1630 and €4240 ± 774, it seems that not only clinical efficacy but

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also long-term cost-effectiveness of PAE in this setting still has to be demonstrated.

In conclusion, in-hospital costs tend to be higher for TURP than for PAE. While consumables are clearly more expensive for PAE, it is associated with cost savings regarding anaesthesia and postoperative expenses. Considering the small cost differences and the different efficacy and safety profiles of PAE and TURP, the present study clearly suggests that the patient's clinical condition and expectations – rather than treatment costs – are the leading factors in determining whether PAE or TURP is chosen.

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Conflicts of Interest

None declared.

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Abbreviation: PAE, prostatic artery embolization.

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