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The Vista System: A New Bipolar Resection Device for Endourological Procedures: Comparison with Conventional Resectoscope

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Abstract

Objective: Conventional transurethral resection of the prostate (TURP) uses a monopolar electrocautery system in which the current passes from the active electrode through the patient's body towards the return plate and may cause distant negative effects. In this study a new developed resection device, the Vista system, using a bipolar electrocautery system and 0.9% sodium chloride solution for irrigation, was evaluated in an ex-vivo model.

Methods: The modified model of the isolated blood perfused kidney was used to determine cutting qualities, ablation rate, blood loss and coagulation depth of the bipolar resectoscope. After ablating the renal tissue of a perfused kidney in a surface area, blood loss was semiquantitatively determined. Afterwards samples were taken and processed for histological evaluation of the coagulation depth. We compared the new bipolar resection device against a conventional monopolar resectoscope.

Results: We found good cutting qualities of the bipolar resectoscope although it is more difficult to start a cut. The ablation rate is determined by the width of the electrode and is similar to the standard device (30 cm^2/min). The bleeding is reduced with increasing output powers (26.13 $\pm$ 6.15 g/min (level 5); 20.49 $\pm$ 5,47 g/min (level 6); 13.16 $\pm$ 5,47 g/min (level 7); 10.43 $\pm$ 4.76 g/min (level 8) and lower compared to a conventional monopolar resectoscope (17.08 $\pm$ 4.47 g/min). The coagulation depth increases with higher output powers but is reduced compared to the standard device (118 $\pm$ 22 μm (level 5); 121 $\pm$ 23 μm (level 6); 141 $\pm$ 62 μm (level 7); 163 $\pm$ 30 μm (level 8) versus 287 $\pm$ 57 (monopolar resectoscope)).

Conclusion: Our results with the bipolar resection device for TURP suggest that it may offer an alternative to conventional TURP. As active and the return electrode are placed on the resectoscope, high current densities are achieved locally and complications caused by distant negative effects of the current are theoretically reduced in vivo. Furthermore the risk of TUR syndrome is theoretically eliminated by using physiological sodium chloride solution for irrigation.

To prove the clinical significance of our ex-vivo findings, clinical studies including large numbers of patients have to be performed.

Keywords: Benign prostatic enlargement; TURP; Bipolar resectoscope; Bleeding

1. Introduction

At present, transurethral resection of the prostate (TURP) is predominant in the surgical therapy of

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benign prostatic enlargement. It is characterized by immediate treatment success due to removal of the infravesical obstruction and produces a long-lasting improvement of symptoms and voiding parameters [1].

However TURP is an invasive surgical method and high perioperative morbidity such as blood loss with the related risk of infection from blood transfusions and TUR-syndrome due to irrigation fluid absorption have been reported [2–4]. In the search for new technologies to reduce morbidity various alternative treatment devices, e.g. interstitial laser therapy, needle ablation, high intensity focused ultrasound, microwave therapy or electrovaporization, have been introduced [5–9]. However standard loop TURP is still regarded as the reference standard method in which urologists have been well trained and remain confident in its use.

Contemporary TURP uses a monopolar electrocautery system in which the current passes through the patient's body from the active electrode, placed on the resectoscope, towards the return plate, normally placed on the patient's leg. This has several disadvantages such as heating of deeper tissue, nervous or muscle stimulation and possible malfunction of cardiac pacemakers [10,11]. In the face of these disadvantages, resectoscopes using bipolar electrocautery offer an alternative. As active and return electrode are placed on the same axis on the resectoscope high current densities are achieved locally and distant negative effects are reduced.

Another risk of standard monopolar TURP is the absorption of hypoosmolar irrigation fluid during extended procedures causing the TUR syndrome. As bipolar resectoscopes use physiological sodium chloride solution for irrigation, the risk of TUR syndrome is theoretically eliminated.

The first bipolar device for endourological procedures was the Gyrus device using bipolar electrocautery to electrovaporize the prostate [12].

In this study we investigated the Vista system (ACMI Corporation, Southborough, MA, USA), a new developed resection device using bipolar electrocautery and saline solution for irrigation. The bipolar resection system comprises the resectoscope and the matching generator (Vista CTR, ACMI Corporation) by which it is activated. The generator works with fixed output voltage levels in the ablation and coagulation mode. The output voltages in the ablation mode at different levels are indicated in Table 1.

The bipolar resectoscope (VISTA system, ACMI Corporation) uses a cutting loop (5 mm loop wire diameter) and a second loop, bent in the same direction, working as return electrode. Both are placed on the same axis on the resectoscope and the current flows between them, providing a localized energy field (Fig. 1).

Table 1
Output voltage of the bipolar HF-generator at different fixed levels in the ablation mode according to the manufacturer

Level	Output voltage (V_{rms} ± 10%)
1	100
2	125
3	150
4	175
5	200
6	225
7	250
8	275

The high-frequency energy passes through the conductive irrigation solution (0.9% sodium chloride solution), which is in contact with the tissue to be resected, from the active to the return electrode. The irrigation solution forms a thin layer between the electrodes. In the ablation mode, if sufficient energy is applied, the conductive solution is converted into a vapour layer (plasma) containing energy charged particles. When these high-energy charged particles come in contact with the tissue, they cause its disintegration through molecular dissociation. Compared to conventional monopolar resection systems this leads to lower temperatures at the treatment site, so that the thermal damage of the surrounding tissue is reduced.

In this study the Vista system was investigated in an ex-vivo model to determine its cutting qualities, ablation rate, blood loss and coagulation depth and compared it to a standard monopolar resectoscope.

2. Material and methods

2.1. Equipment

The bipolar resection system (Vista system) was activated by the matching generator (Vista CTR, ACMI Corporation). 0.9% sodium chloride solution was used as irrigation fluid.

The bipolar resection device was compared to a standard monopolar resectoscope with 5 mm loop wire diameter (Karl Storz, Tuttlingen, Germany) using Purisole SM (standard monnitol/

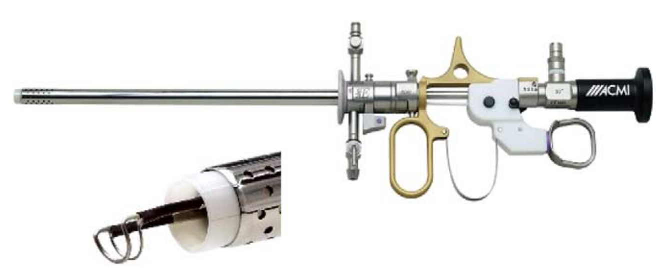

Fig. 1. Bipolar resection device: the Vista system with tip (enlarged).

sorbiol solution for TUR; Fresenius, Bad Homburg, Germany) for irrigation. The monopolar resectoscope was activated by the Autocon 400 II high-frequency generator (Karl Storz) using an output power of 160 Watt, coagulation degree 4.

2.2. Ex-vivo experiments

To determine cutting qualities, ablation rate, blood loss and coagulation depth we used a modified model of the isolated blood-perfused porcine kidney as described previously [13]. The kidneys were removed from pigs within the first 5 minutes after slaughtering (Mannheim city slaughterhouse). After catheterization of the renal artery with a 10 F catheter the kidneys were perfused with 0.9% sodium chloride solution until the effluent was clear. The kidneys were stored at 4 °C before commencing the trial.

During the experiments the kidneys were perfused by a roller pump. To achieve a constant perfusion pressure the pump delivered the perfusion solution over an air chamber via the 10 F catheter, placed in the renal artery.

The perfusion pressure was set to 110–130 cmH_2O resulting in a perfusion rate of 60–100 ml/min. The kidneys were placed on a neutral electrode in an acryl glass basin and fixed. After removing the renal capsule a surface area of 9 cm^2 (3×3 cm) was ablated with a drag speed of 1 cm/s (timed with a stop watch) under permanent perfusion. All experiments were carried out at room temperature. The blood loss was semi quantitatively determined by weighing a swab before and after it was placed on the bleeding surface for 60 seconds. $n = 5$ measurements were performed per output power level. The weight difference marked the amount of blood loss per minute. Afterwards $n = 5$ samples per output power level were taken, fixed in 10% formalin and processed for histological evaluation. Hematoxylin-eosin staining was used and the depths of the coagulation zones were determined under the microscope. Five measurements per slide were performed.

Statistical data is presented as mean ± standard deviation. Statistical significance was evaluated using the unpaired student *t*-test. A *p*-value <0.05 was considered to be statistically significant.

3. Results

We used the modified model of the isolated blood perfused porcine kidney to test the cutting qualities of the new bipolar resection device. In our ex-vivo model satisfactory cutting is only possible using the pre-set levels 5 to 8. It is especially difficult to start a cut. Once the cutting electrode is submerged in the tissue, cutting becomes easier so that accurate and effective cuts are possible.

The ablation rate is determined by the loop wire diameter. A loop wire diameter of 5 mm and a drag speed of 1 cm/sec results in an ablation rate of 30 cm^2/min. This is similar to the ablation rate reached with the monopolar resectoscope, which also has a loop wire diameter of 5 mm. Next, the amount of blood loss was determined using the new bipolar resection device at different HF-generator parameter settings and compared against the conventional monopolar resectoscope. Fig. 2 displays the bleeding rates of the bipolar resection device at different HF-generator output power levels and compares them to the standard monopolar resectoscope ($n = 5$ per output power level). As shown, bipolar resection at level 7 and level 8 exhibits a statistically significantly lower bleeding rate ($p < 0.05$) than the conventional resection. Using an output power of 160 Watt; coagulation degree 4 the bleeding rate is 17.08 ± 4.57 g/min for the monopolar resectoscope. The bleeding rate is significantly reduced for the bipolar device resulting in 13.16 ± 5.47 g/min (level 7) and 10.43 ± 4.76 g/min (level 8).

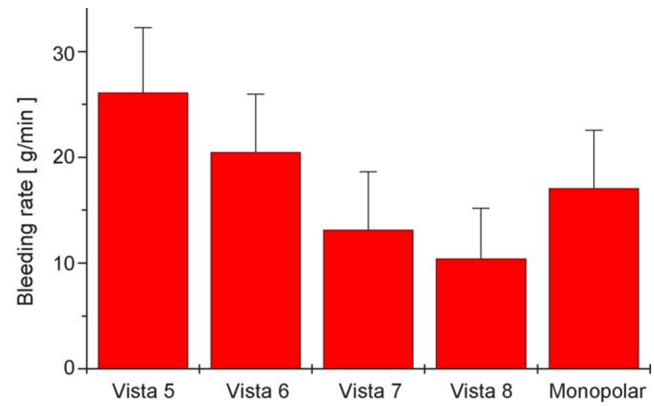

Fig. 2. Comparison of bleeding rate between the monopolar resectoscope (160 Watt, coagulation degree 4) and the bipolar resectoscope at different output power levels (levels 5–8). Using level 7 and level 8 bleeding is significantly reduced ($p < 0.05$) compared to the monopolar device.

Finally samples of the ablated renal surface area were taken and processed histologically ($n = 5$ per output power level). After HE-staining the depths of the coagulation zones were measured under the microscope. The results are displayed in Fig. 3. It becomes clear that with increasing output powers the depths of the coagulation zones increase when the bipolar resection device is used. Compared to the measurements with the

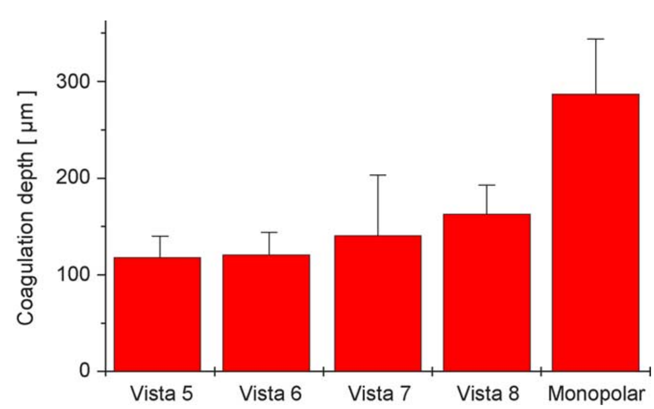

Fig. 3. Comparison of coagulation depth caused by the monopolar resectoscope (160 Watt, coagulation degree 4) and the bipolar resectoscope at different output power levels (levels 5–8). Coagulation depth is significantly smaller ($p < 0.05$) using the bipolar resection system compared to the monopolar resectoscope.

conventional monopolar resectoscope, the depths of the coagulation zones are significantly smaller ($p < 0.05$) indicating a reduced effect on deeper tissue. The coagulation depths were $118 \pm 22\ \mu m$ (level 5); $121 \pm 23\ \mu m$ (level 6); $141 \pm 62\ \mu m$ (level 7) and $163 \pm 30\ \mu m$ (level 8) for the bipolar resectoscope and $287 \pm 57\ \mu m$ for the monopolar resectoscope.

4. Discussion

Although in the last two decades various alternative treatment devices have been introduced, TURP remains the gold standard in surgical treatment of the benign prostatic enlargement. In the search to optimize the standard method, a new resection device has been developed using bipolar electrocautery rather than the conventional monopolar electrocautery and 0.9% sodium chloride solution as irrigation fluid. The aim of our study was to test this new resection device concerning cutting qualities, ablation rate, bleeding rate and coagulation depth.

Our ex-vivo findings indicate that the new device is well suitable to ablate tissue. Although the ex-vivo experiments suggest slightly worse cutting qualities compared to a standard monopolar resectoscope, precise and effective cutting is possible.

The tissue ablation rate, defined by drag speed and wire loop diameter, was found to be similar to the standard device using the same loop wire diameter. This is an advantage over other alternative surgical treatment devices, which often exhibit a reduced tissue ablation rate resulting in prolonged procedures [13,14].

Our findings suggest that intraoperative bleeding may be reduced by using the bipolar resectoscope. In the ex-vivo experiments the bleeding rate is significantly reduced compared to the standard monopolar resection device when the high output voltage levels are used.

In contrast to this the coagulation zones are found to be smaller when the bipolar resectoscope is used. This indicates that the bipolar electrocautery produces indeed a locally limited energy field in which high power densities are achieved between the electrodes at the resectoscope. This high energy field effectively coagulates bleeding vessels at the surface of the resected tissue. Deeper tissue layers are affected less indicating that no energy is ‘‘wasted’’ to them. As the maximum energy field is limited to the resected tissue, distant negative effects, such as deep tissue heating, nervous or muscle stimulation and interfering with cardiac pacemakers, are theoretically reduced in-vivo.

Another advantage of bipolar versus monopolar electrocautery lays in the use of 0.9% sodium chloride solution for irrigation. Therefore the risk of TUR syndrome, resulting from the absorption of large amounts of irrigation fluid during prolonged procedures, is theoretically eliminated.

So far no clinical studies have been performed comparing the Vista system to conventional monopolar TURP. First clinical results with the ‘‘Gyrus device’’, a device using bipolar plasma kinetic technology to electrovaporize the prostate are promising. As the Vista system the Gyrus uses bipolar electrocautery and sodium chloride solution as irrigation fluid. Botto et al. found no significant intraoperative bleeding in 42 treated patients and the reported duration of the procedure appeared similar to that of TURP [12]. Eaton and collegues reported about transurethral prostatectomy using bipolar plasma kinetic vaporization of the prostate on a day-case basis. They found no electrolyte disturbances intraoperatively and bleeding was minimal, so that no patient required a blood transfusion [15]. Boths trials provide only short follow-up information (3 months and 4 months follow-up) which show an improvement in symptoms (IPSS) and voiding parameters (peak flow rate).

Dunsmuir and collegues report about a randomized prospective study comparing bipolar electrovaporization of the prostate with the Gyrus device to conventional TURP. After a one year follow-up symptom scores, quality of life, flow rates and post-void residual volumes were similar. The reported re-catheterization rate was higher (30% vs. 5%) in the bipolar vaporization group, the rate of postoperative clot-evacuation was higher in the conventional TURP group. They reach the conclusion that bipolar electrovaporization of the prostate with the Gyrus device is safe and produces similar results to TURP after one year [16].

All these clinical trials emphasize on the low intraoperative and postoperative bleeding when the bipolar device is used. No incidence of hyponatiemia or TUR syndrome is reported as this is theoretically prevented by the use of 0.9% sodium chloride solution. As these trial were performed with a device to electrovaporize the prostate they cannot be directly transferred to the Vista system which performs a resection of the prostate.

Unlike other alternative surgical treatments, such as electrovaporization, microwave therapy, needle ablation, radiofrequency ablation or high intensity focussed ultrasound, bipolar TURP offers the possibility of gathering samples of the resected prostatic tissue for histological evaluation. Another treatment option offering the possibility to gather the resected prostatic tissue for histological analysis is the holmium laser enucleation of the prostate when the mushroom technique is used. In this technique the prostatic lobes are enucleated with a holmium laser yust short of completion until attached to the capsule by a narrow mushroom-like stalk. As the vascular supply is almost interrupted at that point, they can be electroresected into small pieces without bleeding. This technique combines the advantages of the bloodless holmium laser enucleation and the electroresection of the prostate [17].

In conclusion transurethral resection of the prostate using a bipolar electrocautery system offers a promising alternative to conventional monopolar resectoscopes. Our ex-vivo findings indicate a reduced intraoperative blood loss whereas cutting qualities and ablation rate are comparable to the monopolar device. Clinical studies are necessary to prove if there is a significant benefit for the patient.

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