Use of the AccuVein AV400 during RARP: an infrared augmented reality device to help reduce abdominal wall hematoma

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LAW KW, AJIB K, COUTURE F, THOLOMIER C, BONDARENKO HD, PREISSER F, KARAKIEWICZ PI, ZORN KC. Use of the AccuVein AV400 during RARP: an infrared augmented reality device to help reduce abdominal wall hematoma. *Can J Urol* 2018; 25(4):9384-9388.

Introduction: *Abdominal wall hematoma (AWH) is a self-resolving, yet common complication from the insertion of trocars during laparoscopic surgery. Particularly, its appearance may increase patient anxiety and may reduce overall surgical satisfaction.*

Materials and methods: *In a retrospective study analyzing data from 724 robot-assisted radical prostatectomy cases (RARP), trocar insertion sites were examined on postoperative day 7 with Foley removal for AWH. AWH was defined by a sizable collection of blood below the skin as a result of the surgery. The AccuVein AV400 system was utilized to generate real-time images of venous structures beneath the skin. Comparative outcomes were performed with a series of 114 men where the AccuVein AV400 device was applied over trocar insertion markings to help modify port placement.*

Results: *The pre-incision imaging of the AccuVein system modified port placement in 74 of 114 cases (65%), and reduced AWH from 8.8% to 2.6% ($p = 0.03$) as compared to transabdominal illumination. Port placement adjustments were most prevalent in the lateral regions of the abdomen, prompting attention for lateral trocar insertion to avoid vessels such as the thoracoepigastric veins. Notably, the body mass index (BMI) of patients experiencing AWH who received the pre-incision imaging of AccuVein was significantly higher than patients receiving standard transabdominal illumination (34.2 and 27.9 kg/m^2 respectively; $p = 0.02$).*

Conclusion: *The AccuVein AV400 device appears to be an effective adjuvant for decreasing rates of AWH during lower abdominal wall trocar insertion, though its effectiveness is limited in patients with extreme BMI. Additionally, special attention should be directed towards trocar insertion in the lateral regions of the abdomen.*

Key Words: abdominal wall hematoma, trocar insertion

Introduction

Over the past 2 decades, urologic procedures have increasingly utilized laparoscopic techniques with advantages of reduced hospital stay, lower patient morbidity, and decreased blood loss compared to conventional surgery.[1,2] Despite the many technical advances in laparoscopic surgery equipment and the extensive experience of many surgeons, there are still a number of complications from insertion of trocars.[1-3] Although not often life threatening and self-resolving, abdominal wall hematoma (AWH) induced by laparoscopic trocar placement is common and not well reported in the literature.[4] AWH's unsightly appearance and its associated pain and swelling[5] may increase patient anxiety and detract from the surgical experience.

Traditionally, port placement is guided by anatomical landmarks based on the location of the pubic bone and modified using transabdominal illumination techniques, though the primary trocar to establish laparoscopic access and pneumoperitoneum is often not inserted under any visual guidance (Veress needle access).[6]

The AV400 system (AccuVein Inc, NY, USA) has been reported to be a successful adjuvant to locate veins and

Accepted for publication July 2018

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aid in intravenous cannulation for IV access, cosmetic surgeries and anesthesia, and was found to be useful in difficult patients (obese, dark-skinned).[7,8] It is a non-invasive, hand-held device that utilizes infrared light to generate a real-time augmented reality image of patients' venous blood vessels by visualizing hemoglobin, Figure 1a. Furthermore, the device is portable and lightweight, and requires only seconds to function. To the best of our knowledge, the use of this device in abdominal surgery has not been reported. Herein, we report our experience of the pre-incision use of the AccuVein device compared to standard transabdominal illumination to help modify laparoscopic port placement.

Materials and methods

Patient population

After obtaining institutional review board approval, prospective data from 724 robot-assisted prostatectomy (RARP) cases performed by an expert high-volume surgeon were reviewed and analyzed retrospectively. Treatment indications were in accordance with the American, Canadian and European clinical practice guidelines.[9-11] All men requiring anti-platelet and anti-coagulant therapy stopped medication 7 days prior to operation and resumed postoperatively 5-7 days later.

Surgical technique

All RARP cases in the control group were performed using a standardized six port placement with non-bladed trocars with transabdominal illumination as previously described.[12] Surgical technique of an intra-peritoneal, initial posterior approach RARP has been previously described.[13] Use of the AV400 was employed in the study group instead of transabdominal illumination by the unscrubbed surgical team over the sterile field and pre-marked standardized trocar locations determined by anatomical landmarks, Figure 1b.[12] Modifications to trocar placement were recorded, Figure 2.

Covariates

All men undergoing RARP received preoperative evaluation recommended by the American Urological Association (AUA) prior to undergoing surgical intervention.[10] Preoperative variables collected in our prospectively maintained database included: patients' age, body mass index (BMI), preoperative PSA, prostate biopsy Gleason score and Clinical TNM staging. A transrectal ultrasound (TRUS) was used to measure initial prostate volume during diagnostic prostate biopsy. Perioperative variables including operative time, calculated blood loss and nerve preservation were recorded. Furthermore, postoperative characteristics recorded included hospital stay (days) and perioperative blood transfusion.

Endpoints

All trocar sites were visually examined on postoperative day (POD) 7 with Foley removal in office. AWH was defined by a sizable collection of blood below the skin, resulting from a complication following surgery, Figure 3. Unfortunately, there are no standardized hematoma

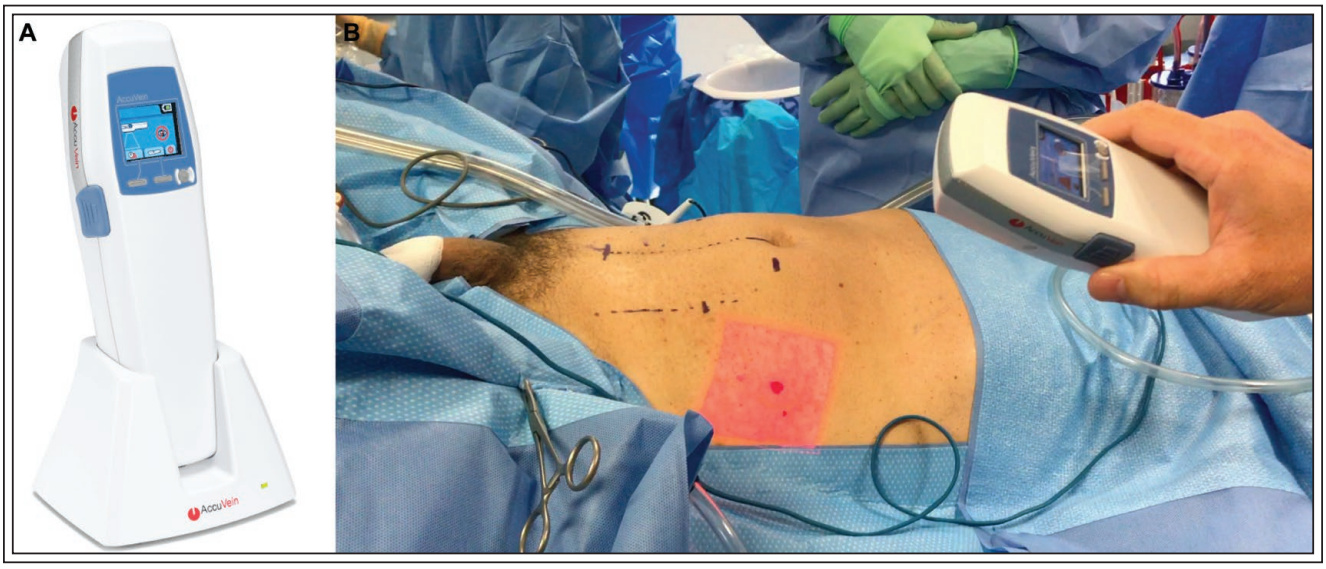
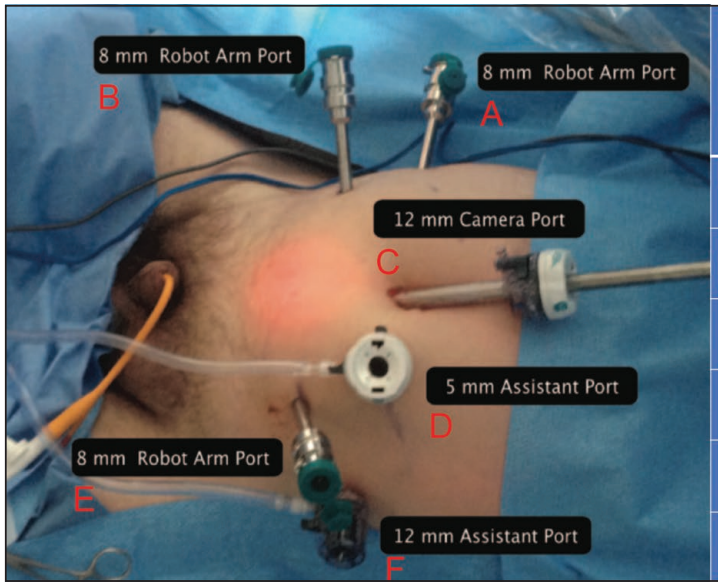


Figure 1. AccuVein AV400 device **(A)** utilizing infrared light to generate a real-time image of venous structures in order to validate standard trocar insertion point markings **(B)**.



Port	Required Adjustment
A	**49/114 (43%)**
B	24/114 (21%)
C	1/114 (0.8%)
D	6/114 (5%)
E	21/114 (18%)
F	**42/114 (37%)**

Figure 2. Common adjustments of trocar placement proceeding the pre-incisional imaging of the AccuVein system. AccuVein imaging was applied over the standard six-port markings for robot assisted radical prostatectomy in 114 men and necessary trocar placement adjustments were noted.[12]

measures. Consequently, any purple discoloration with tracking beneath the skin were identified and considered a hematoma. Comparative outcomes were performed with a series of 114 consecutive men where the AccuVein AV400 was applied over the standardized trocar markings prior to incision. Adjustments to trocar insertion points were made if venous vessels were identified at the location of the trocar markings. Necessary adjustments were recorded along with hematoma related outcomes.

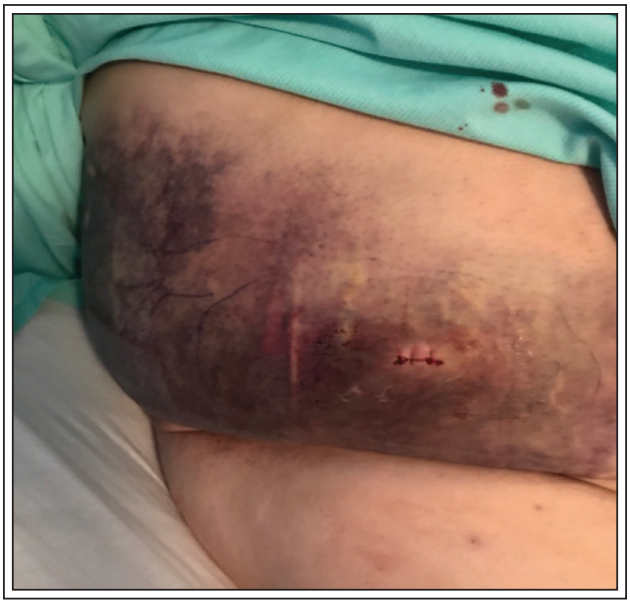


Figure 3. Example of AWH on POD 7. Patient had undergone RARP performed using a standardized six port placement with non-bladed trocars with transabdominal illumination.

Statistical analysis

Student's t-test and chi-squared tests were performed using R software environment for statistical computing and graphics (Vienna, Austria, version 3.0.1). All tests were 2-sided with a significance level set at $p < 0.05$.

Results

Baseline characteristics

Overall, 724 RARP cases were retrospectively analyzed. Between control (n = 610) and AccuVein patients (n = 114), there were no significant differences in preoperative characteristics (age, BMI, preoperative PSA, TRUS prostate volume, biopsy Gleason score or clinical TNM staging) or perioperative characteristics (operative time, calculated blood loss, nerve preservation), as demonstrated in Table 1.

Trocar adjustments

There were modifications to trocar placement in 74 of the 114 patients (65%) analyzed with the AccuVein system. The most common adjustments were observed along the lateral surgical field, Figure 2.

TABLE 1. **Preoperative and perioperative characteristics and outcomes between control and AccuVein utilized RARP patients. All cases were performed using a standardized six port placement with non-bladed trocars with transabdominal illumination.**

Mean	Control group (n = 610)	AccuVein AV400 group (n = 114)	p value
Age	62.3	61.8	0.65
BMI (kg/m^2)	27.2	27.7	0.72
Preoperative PSA (ng/mL)	5.4	5.6	0.58
TRUS prostate volume (mL)	39	44	0.48
Biopsy Gleason score (%)			0.18
6	180 (29%)	26 (22%)	
7	390 (64%)	83 (73%)	
8-10	40 (7%)	5 (5%)	
Clinical TNM stage (%)			0.07
cT1c	428 (70%)	88 (77%)	
cT2	179 (29%)	21 (21%)	
cT3	3 (1%)	2 (2%)	
Perioperative outcomes			
Operative time (min)	162	159	0.54
Calculated blood loss (mL)	178	173	0.62
Nerve preservation (%)			0.68
Bilateral	395 (64%)	76 (67%)	
Unilateral	111 (18%)	17 (15%)	
Hospital stay (days)	1.1	1.1	0.86
Perioperative transfusion	3 (0.4%)	0	0.45
POD 7 incisional hematoma	54 (8.8%)	3 (2.6%)	0.03
⇒ Mean BMI (kg/m^2)	27.9	34.2	0.02
⇒ Hospitalization >1 d	17	1	0.94
⇒ Transfusion	3	0	0.45

BMI = body mass index
PSA = prostate-specific antigen
TRUS = transrectal ultrasound

POD 7 incisional hematoma

Among the 610 men operated using conventional technique for trocar placement (anatomical landmarks and transabdominal illumination), 54 (8.8%) experienced abdominal wall hematoma, while 3 (2.6%) of the 114 men receiving the pre-incisional imaging of the AccuVein system experienced AWH (p = 0.03). Notably, the BMI amongst patients who experienced AWH in the AccuVein study group (34.2 kg/m^2) was significantly higher than patients who experienced AWH in the control group (27.9 kg/m^2; p = 0.02). There were no significant differences in extended hospitalization times or transfusions associated with AWH between the two groups.

Discussion

Our results demonstrated that the pre-incisional use of the AccuVein system in men who had undergone RARP significantly reduced rates of surgery-induced AWH from 8.8% to 2.6% (p = 0.03), as compared to traditional port adjustment with standard transabdominal illumination. As expected, the majority of AWH cases were self-limited and resulted in few extended hospitalizations or required transfusions. Thus, the application of the AccuVein system did not yield any significant reductions in AWH-associated prolonged hospitalization time or transfusion. Nonetheless, significant reductions in AWH results in quicker recovery and return to normal activity.[14]

More important, from a surgical perspective, there were modifications to trocar placements in 74 of the 114 patients (65%) analyzed with the AccuVein system, with the majority of modifications occurring in the lateral abdominal regions, Figure 2. This suggested that anatomical landmarks were not effective measures in locating lateral venous structures. In addition, considerable anatomical variation may have made it difficult to identify superficial venous structures such as the thoracoepigastric veins, lumbar veins and superficial inferior epigastric veins.[15] On the other hand, the direct visualization provided by the AV400 system allowed necessary adjustments in the lateral abdominal area to account for vascular variation and reduce potential AWH.

Patients who experienced AWH postoperatively, the mean BMI for those who had received pre-incisional analysis with the AccuVein AV400 was significantly higher than those in the control group (34.2 versus 27.9 kg/m^2, respectively; $p = 0.02$). Obese men present challenges in the operating room as they have thicker anterior abdominal walls, often prolongating operative times in robotic and laparoscopic surgery.[6] Thicker layers of abdominal adipose tissue complicate the placement of trocars, as vasculature underneath a deep layer of adipose tissue may not be visualized through traditional transabdominal illumination. Similarly, the AccuVein infrared system is limited to visualizing vasculature up to 10 mm beneath the skin, thus deeper venous structures would be difficult to identify. In turn, pre-incisional AccuVein analysis was an effective tool to reduce rates of AWH in patients of lower BMI, but not in patients of higher BMI.

The AccuVein system is not indicated for the insertion of laparoscopic trocars, however our findings suggest that it is a novel and effective adjuvant in reducing rates of AWH. Despite its merits, our study is not devoid of limitations. Due to the retrospective design of our study, patient groups were not randomized. The AccuVein device was used in all RARP cases subsequent to its first implementation. Additionally, we were unable to explore whether the AccuVein system was more effective in reducing AWH in darker skinned patients, as it has been reported that venous structures are more difficult to identify with darker skin pigmentation.[7] Moreover, no patient satisfaction or pain measure validated questionnaires were implemented pre or postoperatively, thus it remains unknown whether reductions in AWH and its accompanying complications truly improves patient satisfaction of the surgical experience. Finally, all procedures were performed by a single surgeon with high operative volume beyond the learning curve. This is a possible limitation to the generalization of the system's effectiveness in aiding with trocar insertion within other medical settings.

Conclusion

Our study helps report on AWH during RARP, which is noteworthy and underreported in the literature. AWH often does not require prolonged hospitalization or blood transfusion. Application of the AccuVein AV400 augmented reality, real-time venous visualization system appears to help avoid unrecognized subcutaneous venous networks, which can be injured during trocar placement. Attention should be made for the insertion of lateral trocars for men undergoing RARP. Additionally, men with extreme BMI still present a challenge to trocar insertion. Further studies are warranted in other abdominal surgical applications. □

References

1. Karadag MA, Cecen K, Demir A et al. Gastrointestinal complications of laparoscopic/robot-assisted urologic surgery and review of literature. *J Clin Med Rec* 2015;7(4):203-210.
2. Simforoosh N, Baisiri A, Ziaee S et al. Major vascular injury in laparoscopic urology. *J Soc Laparoendosc Surg* 2014;18(3):1-5.
3. Velilla G, Redondo C, Sánchez-Salas R et al. Visceral and gastrointestinal complications in robotic urologic surgery. *Actas Urol Esp* 2018;42(2):77-85.
4. Schäfer M, Lauper M, Krähenbühl L. A nation's experience of bleeding complications during laparoscopy. *Am J Surg* 2000; 180(1):73-77.
5. Hindman NM, Kang S, Parikh MS. Common postoperative findings unique to laparoscopic surgery. *Radiographics* 2014;34(1)119-138.
6. Gaunay G, Elsamra S, Richstone L. Trocars: site selection, instrumentation and overcoming complications. *J Endourol* 2016; 30(8):833-843.
7. Chu MW, Sarik JR, Wu LC et al. Non-invasive imaging of preoperative mapping of superficial veins in free flap breast reconstruction. *Arch Plast Surg* 2016;43(1):119-121.
8. Kaddoum R, Anghelescu DL, Parish ME et al. A randomized controlled trial comparing the AccuVein AV300 device to standard insertion technique for intravenous cannulation of anesthetized children. *J Paediatr Anaesth* 2012;22(8):884-889.
9. Carter HB, Albertsen PC, Barry MJ et al. Early detect of prostate cancer: AUA Guideline. *J Urol* 2013;190(2):419-426.
10. Rendon RA, Mason RJ, Marzouk K et al. Canadian Urological Association recommendations on prostate cancer screening and early diagnosis. *Can Urol Assoc J* 2017;11(10):298-309.
11. Heidenreich A, Bastian PJ, Bellmunt J et al. EAU guidelines on prostate cancer. Part 1: screening, diagnosis, and local treatment with curative intent – update 2013. *Eur Urol* 2013;65(1):124-137.
12. Valdivieso RF, Hueber PA, Zorn KC. Robot assisted radical prostatectomy: how I do it. Part I: patient preparation and positioning. *Can J Urol* 2013;20(5):6957-6961.
13. Valdivieso RF, Hueber PA, Zorn KC. Robot assisted radical prostatectomy: how I do it. Part II: surgical technique. *Can J Urol* 2013;20(6):7073-7078.
14. Martín-Malagón A, Arteaga I, Rodríguez L et al. Case report: abdominal wall hematoma after laparoscopic surgery: early treatment with selective arterial transcatheter embolization. *J Laparoendosc Adv Surg Tech A* 2007;17(6):781-783.
15. Rozen WM, Chubb D, Whitaker IS et al. The Importance of the superficial venous anatomy of the abdominal wall in planning a superficial inferior epigastric artery (SIEA) flap: case report and clinical study. *Microsurgery* 2011;31(6):454-457.