World Journal of Urology (2019) 37:173–179
https://doi.org/10.1007/s00345-018-2351-2

ORIGINAL ARTICLE

Validating the role of ABO blood type in risk of perioperative venous thromboembolism after radical cystectomy

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Received: 10 January 2018 / Accepted: 25 May 2018 / Published online: 6 June 2018

Abstract

Purpose To validate the relationship between ABO blood type and risk of VTE post-RC in a large retrospective database.

Methods Patients with urothelial bladder cancer (UBC) who underwent RC (intent-to-cure) for whom ABO blood type was available between 2003 and 2015 were identified from our IRB-approved database. VTE was defined as deep vein thrombosis (DVT) or pulmonary embolism (PE) within 90 days of surgery. VTE prophylaxis consisted of immediate postoperative Coumadin (2003–2009), unfractionated heparin (UFH) during hospitalization (2009–2015), and UFH during hospitalization plus 4 weeks of enoxaparin after discharge (2013–2015). Univariable and multivariable analyses of the association of ABO blood type with postoperative, symptomatic VTE and oncologic outcomes were performed.

Results Of 1341 patients, 595 (44.4%) were ABO type O and 746 (55.6%) were non-O (A, B and AB). 90 patients were diagnosed with VTE within 90 days of surgery (6.7%) (43% DVT-only, 57% PE ± DVT). On multivariable analysis non-O blood type was associated with a nearly twofold increased risk of VTE (OR = 1.94, 95% CI 1.215–3.098, $p = 0.004$). No difference in recurrence-free survival or overall survival was seen between ABO groups.

Conclusion Non-O blood type is an independent, non-modifiable risk factor for postoperative VTE after RC. More comprehensive counseling and thromboprophylaxis should be considered in this high-risk group.

Keywords MeSH · Cystectomy · Venous thromboembolism · Urothelial carcinoma · Bladder · Thromboprophylaxis

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Introduction

Radical cystectomy (RC) carries the highest risk of postoperative VTE in urologic surgery and is associated with significant morbidity and mortality. Surveys of the Nationwide Inpatient Sample (NIS) and American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) databases found symptomatic VTE rates of up to 6%, with over half of diagnoses being made after discharge [1–3]. VTE in this setting was associated with increased hospitalization costs and up to five times the risk of in-hospital mortality [1, 4]. Given this, risk-stratification and VTE prevention for patients undergoing RC for bladder cancer has come into focus. The 2014 American Urological Association (AUA) best practice statement for VTE prevention recommended that these patients should be considered high risk and emphasized the importance of pharmacologic prophylaxis, although these recommendations focused only on anticoagulation during hospitalization [5].

In addition to malignancy and pelvic surgery, several risk factors for postoperative VTE after RC have been identified, including body mass index, surgical margins, diversion type, length of hospitalization, age, sepsis and neoadjuvant chemotherapy [1, 6, 7]. Recently, ABO blood type has also been identified as a potential genetic risk factor for the development of VTE after radical prostatectomy [8] and RC [9], with non-O blood type (A, B, or AB) conferring an increased risk of VTE. Wang et al. [9] were the first to report this association in RC; however, details regarding thromboprophylaxis were largely unavailable in their cohort that spanned almost 30 years, and only 25% of patients received prophylaxis at all.

Herein, we attempt to validate the protective role of blood type O in the formation of VTE after RC using a large institutional database that includes detailed information about thromboprophylaxis. By better understanding non-modifiable risk factors for VTE in this setting, we hope to improve our ability to tailor management in those that are at highest risk.

Materials and methods

All subjects were part of an IRB-approved database. From 2003 to 2015, 1729 consecutive patients underwent RC for urothelial carcinoma (UC) at our institution. Patients whose surgery was non-intent to cure (T4b, ≥ M1), those with incomplete records and those for whom ABO blood type was not available were excluded, leaving 1341 patients who comprised the study cohort. All patients underwent open RC with extended pelvic lymph node dissection using an institutionally standardized approach as previously described [10].

Phenotypic blood type (A, B, AB, and O) was collected through retrospective review of patient records and then grouped by either blood type O ($n = 595$, 55.6%) or non-O ($n = 746$, 55.6%) (A, B, and AB). VTE was defined as any DVT or PE that presented symptomatically and was confirmed by appropriate imaging (ultrasound, ventilation/perfusion scan or computerized tomography pulmonary angiogram). No screening for asymptomatic VTEs occurred.

Clinicopathologic variables including age, gender, body mass index (BMI), Charlson comorbidity index (CCMI), smoking history, chemotherapy status and pathologic staging were recorded. Intraoperative variables, blood transfusion, diversion type, anticoagulation type and timing, length of stay (LOS) and Enhanced Recovery After Surgery (ERAS) enrollment were examined. 90-day postoperative complications were analyzed and graded by Clavien–Dindo classification.

Anticoagulant use

There were three eras of thromboprophylactic regimens: immediate postoperative Coumadin (2003–2009), postoperative subcutaneous heparin until discharge (2009–2015), and postoperative subcutaneous heparin until discharge plus 28 days of enoxaparin (2013–2015). From 2009 onwards, all patients received 5000 units of heparin prior to incision. In all periods, sequential compression devices were used and early mobilization was emphasized.

Statistical analysis

The chi-square test was used to compare qualitative categorical variables and Wilcoxon test for quantitative data. Univariable and multivariable step-wise logistic regression models were used to identify predictors of VTE. Covariates included age, BMI, cancer stage, node status, and preoperative chemotherapy.

Results

Median length of follow-up for the cohort was 4.6 years. 1063 (79.3%) patients were male. Median age of the cohort was 70, median BMI was 27.1 and median LOS was 8 days. 191 (14.2%) patients received adjuvant while 257 (19.2%) received neoadjuvant chemotherapy. 905 patients underwent an orthotopic urinary diversion (67.4%). 595 (44.4%) patients were blood type O and 746 (55.6%) were non-O (A, B and AB). No significant differences were noted between those with O vs. non-O blood type regarding age, BMI, CCMI, smoking history, LOS, or pathologic stage (see Table 1).

VTE within 90 days of surgery were recorded in 90 patients (6.7%), of which 39 (43%) were DVT only, and 51 (57%) were pulmonary embolism with or without DVT. The median time to diagnosis of VTE was 20.5 days from surgery. Documented thromboprophylaxis information was available and confirmed for 1187 patients (89%). 428 patients received immediate postoperative Coumadin (2003–2007), 407 received heparin preoperatively and every 8 h until discharge (2007–2012), and 352 received this in addition to 28 days of low-molecular weight heparin (LMWH) after discharge (2013–2015).

There were no differences in complication rates between blood groups in regards to overall complications or grade at 30 days ($p = 0.43$) or 90 days ($p = 0.18$); there were no differences in bleeding complications between different prophylaxis regimens (see Table 2). In patients who experienced VTE, there were nine high-grade complications at 90 days,

Table 1 Patient characteristics and perioperative outcomes by ABO blood type

Variable (median) (%)	Non-O (A, B, AB) ($n=746$)				Total non-O	p-value
	O ($n=595$)	A ($n=520$)	B ($n=163$)	AB ($n=63$)		
Age (years)	70.3	70.2	70.5	70.8	70.3	0.24
Female	122 (21)	106 (21)	37 (23)	13 (21)	156 (21)	0.44
BMI (kg/m^2)	27.4	26.8	26.7	26.7	26.8	0.31
Hospital Stay (days)	8	8	8	8	8	0.08
Operative Time (hours)	5.9	6	5.9	5.7	6	0.25
Orthotopic diversion	418 (70)	342 (65)	109 (66)	36 (57)	487 (65)	0.11
Pathologic stage						
≤pT2	363 (61)	300 (57)	90 (55)	36 (57)	426 (57)	0.8
≥pT3	102 (17)	103 (19)	33 (20)	11 (17)	147 (20)	
pN+	130 (21)	117 (22)	40 (24)	16 (25)	173 (23)	
Chemotherapy						
Neoadjuvant	120 (21)	92 (18)	35 (22)	10 (16)	137 (18)	0.54
Adjuvant	85 (15)	79 (16)	20 (13)	7 (12)	106 (14)	0.7
ERAS (+)	180 (31)	139 (28)	50 (31)	10 (16)	199 (27)	0.07
VTE within 90 days	27 (4.5)	43 (8.2)	15 (9.2)	5 (7.9)	63 (8.4)	0.04

Table 2 30- and 90-day complications excluding VTE stratified by ABO blood type according to Clavien–Dindo grading classification

Complications	ABO blood type				Total	p value
	O	A	B	AB		
30 days						
Low	173 (29%)	146 (28%)	54 (33%)	16 (25%)	389 (29%)	0.43
High	45 (7.5%)	39 (7.5%)	17 (10%)	8 (12%)	109 (8.1%)	
90 days						
Low	195 (32%)	170 (32%)	50 (30%)	17 (26%)	432 (32%)	0.18
High	71 (11%)	57 (10%)	31 (19%)	10 (15%)	169 (12%)	

all of which were in those with PE: seven Grade IVa and two Grade V complications. All Grade IV complications represented transfer to an intensive care unit for some degree of hemodynamic instability. Both mortalities were related to PE. Between blood type O and non-O groups, no differences in 90-day readmission rate, recurrence free survival (RFS) or overall survival (OS) were found (Fig. 1 and 2).

On univariable analysis ≥ pT3 ($p=0.004$), pN+ ($p=0.03$), presence of lymphovascular invasion and adjuvant chemotherapy approached significance at $p=0.07$ and $p=0.06$, respectively. Multivariable logistic analysis was performed controlling for age, BMI, neoadjuvant chemotherapy, and pathologic stage (Table 3). Four predictors of VTE were identified: non-O blood type [OR = 1.94, 95% CI (1.215–3.098), $p=0.004$], BMI [OR = 1.05, 95% CI (1.002–1.090), $p=0.04$], ≥ pT3 [OR = 1.66, 95% CI (1.007–2.722), $p=0.003$], pN+ [OR = 1.32, 95% CI (0.772–2.250), $p=0.02$]. Age older than 65, adjuvant chemotherapy ($p=0.06$), transfusion, margin status, receipt of neoadjuvant chemotherapy and enrollment in our ERAS protocol did not impact the incidence of VTE. No significant difference was observed in the rates of overall VTE, DVT only, or PE with or without DVT between the three prophylactic eras ($p=0.48$).

Discussion

In this large retrospective series of UBC patients undergoing radical cystectomy, we found a 90-day, symptomatic VTE rate of 6.7%. This is comparable to our previous report as well as others in the literature [1, 2, 6]. Four risk factors were identified on multivariable analysis: locally advanced disease, nodal disease, BMI and non-O blood type. Non-O blood type was associated with a nearly twofold increased risk of symptomatic VTE within 90 days after RC compared to those with blood type O [4.5% (27/595) versus 8.45% (63/746)]. Nineteenth day complication rates were not different otherwise. Additionally, ABO blood type did not predict a difference in survival outcomes.

Our study validates the findings of Wang et al., who examined over 2000 RC patients and also found that non-O patients carried a twofold risk of VTE postoperatively. A limitation of the Wang study was that information

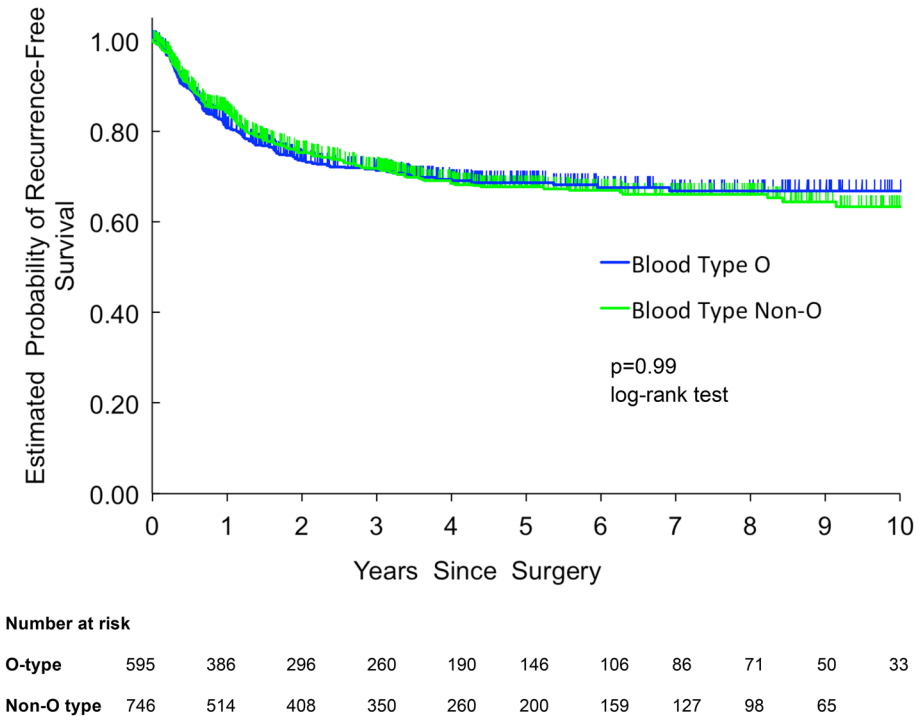

Fig. 1 Kaplan–Meier survival estimates of recurrence-free survival among patients undergoing radical cystectomy for urothelial carcinoma based on ABO blood type. Blue line = patients with ABO type O, green line = patients who ABO type non-O; log-rank test; $p = 0.99$

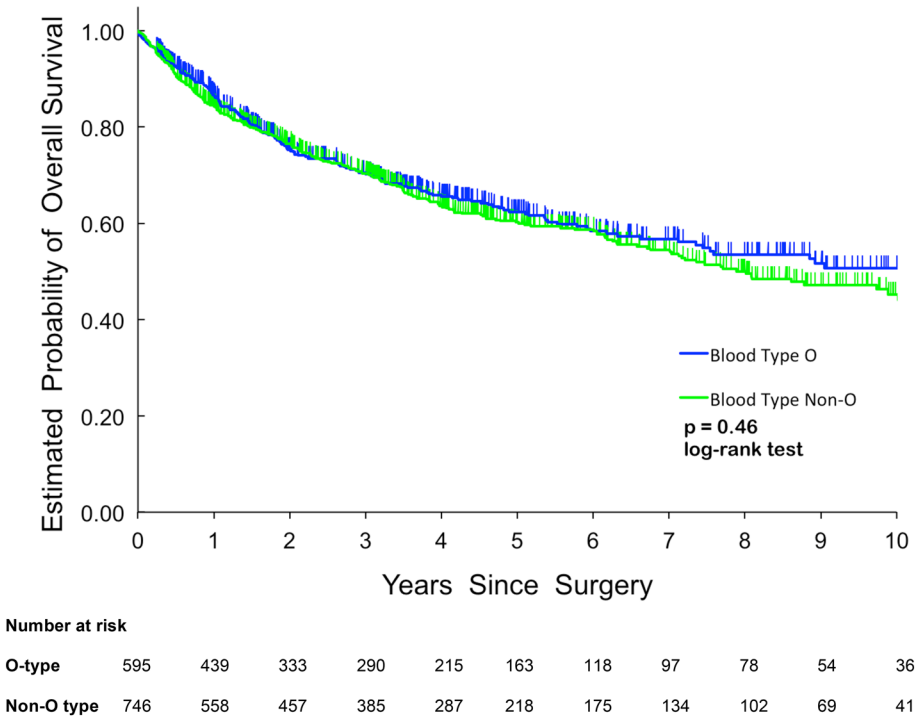

Fig. 2 Kaplan–Meier survival estimates of overall survival among patients undergoing radical cystectomy for urothelial carcinoma based on ABO blood type. Blue line = patients with ABO type O, green line = patients who ABO type non-O; log-rank test; $p = 0.46$

regarding VTE prophylaxis was largely unavailable, likely due to the fact that the cohort spanned nearly three decades. Their survey of the most recent 100 patients showed that 25% received thromboprophylaxis. In this study, we were able to confirm specific prophylactic regimens in 89% of the cohort. 352 (26%) patients received extended prophylaxis with 4 weeks of LMWH after discharge, which reflects current trends of prophylaxis.

The pathophysiologic basis for a link between ABO group and thrombosis has been well described and involves von Willebrand Factor (vWF) [11]. Circulating vWF is a carrier molecule for Factor VIII in serum, preventing its

Table 3 Multivariate logistic regression of venous thromboembolism risk factors

Variables	Odds ratio (95% CI)	*p* value
Non-O (reference = O)	1.94 (1.215-3.098)	0.004
Age	1.011 (0.989-1.033)	0.6
BMI	1.045 (1.002-1.090)	0.04
Pathologic stage		
≥pT3	1.656 (1.007-2.722)	0.003
LN+	1.318 (0.772-2.250	0.02
Neoadjuvant Chemotherapy	0.634 (0.335-1.199)	0.1

degradation and thereby promoting thrombosis. vWF also promotes platelet adhesion by crosslinking platelets to exposed subendothelial collagen via platelet surface receptor GP1B [12]. Individuals with blood type O have an increased rate of vWF clearance compared to non-O blood groups, with a half-life of 10 versus 25.5 h, resulting in 25% lower levels of circulating vWF [13–15] and thereby a less thrombotic environment.

This difference in rate of vWF clearance may be explained by the fact that vWF protein contains sites for glycosylation by *N*-acetylgalactosamine and D-galactose, the glycosyltransferases that determine blood groups A and B, respectively. This glycosylation of vWF with A and B surface antigens in non-O individuals confers resistance to proteolysis by ADAMTS13, the enzyme responsible for the majority of vWF degradation, while the absence of A or B antigens in individuals of blood group O confers an increased susceptibility to proteolysis. [16, 17] Interestingly, our results mirror that of a meta-analysis of over 10,000 surgical and non-surgical cases from the literature which found that VTE incidence in non-O patients was double that of O-type patients making ABO type the biggest genetic determinant of VTE in this analysis [18].

Not only does RC represent the highest VTE incidence in urology, in oncology it is in fact second only to esophagectomy according to a large survey of all commonly performed cancer operations in the United States [19]. However, anticoagulation in this largely elderly population after a surgery with potentially extended convalescence is not without risk, namely, bleeding, the precise risk of which is difficult to ascertain [20]. Of all major guideline statements only that from the AUA offers procedure-specific thromboprophylaxis guidelines, and none clearly address bleeding risk [21]. Tikkinen et al. in a meta-analysis found that overall in both open and robotic RC (>4000 cases) the 4-week symptomatic VTE rate without prophylaxis was 2–12%, and risk of bleeding requiring reoperation was low (0.3%). They concluded from their modeling that prophylactic anticoagulation (largely LMWH) decreased the risk of VTE by 50% and increased the relative risk of major bleeding by 50%; given that risk of significant late bleeding in RC is low, this did not result in a significant increase in risk with anticoagulation [22]. A Cochrane review of major abdominal or pelvic surgery did not find any increased risk of significant bleeding associated with extended LMWH [23].

There are a few additional considerations regarding VTE and anticoagulation in an RC population. The first pertains to the fact that renal insufficiency can result in supratherapeutic levels of LMWH. One group found that after RC up to 43% of patients have a decline in eGFR of which 13% have a drop to the level at which LMWH would become supratherapeutic [20]. A second specific concern in this setting is that cisplatin has generally been associated with increased risk of VTE in malignancy, with a meta-analysis of 38 randomized controlled trials including two urologic trials finding a HR of 1.67 for VTE in patients undergoing cisplatin versus non-cisplatin-based regimens [24]. Furthermore, in a multi-institutional study of 761 patients who received neoadjuvant, cisplatin-based chemotherapy (NAC) prior to RC, Duivenvoorden et al. [7] found a VTE rate of 14%, with 58% presenting pre-operatively. Although in our cohort receipt of cisplatin-based NAC was not associated with increased risk of 90-day VTE, there is good evidence suggesting cisplatin-treated patients should also be considered to be at additionally high risk.

In this study, ABO type was not associated with differences in RFS or OS. Another group recently found that in this setting, patients with non-O type had slightly improved RFS and cancer-specific survival (CSS), which bore out to be a difference seen in only organ-confined patients [25]. This is logical given that once disease is advanced, stage will be driving outcome and not ABO type. In our study, even in patients with ≤pT2 disease, ABO type did not impact RFS or OS. Given that the aforementioned group only found a marginal difference, this is not surprising. Our findings are consistent with two other published series that did not find an association between ABO and oncologic outcomes after RC [26, 27].

The optimal duration of thromboprophylaxis after radical cystectomy remains unclear. After RC, over 50% of symptomatic VTE have been found after discharge, supporting the use of prolonged prophylaxis [1, 6]. A Cochrane review of 4 RCTs of LMWH after major abdominal or pelvic surgery found that overall, 4 weeks of prophylaxis reduced the rate of DVT (asymptomatic and symptomatic) from 14 to 6%, with no increase in bleeding risk [23, 28]. Recently, Pariser et al. [29] retrospectively compared symptomatic VTE rates between 234 patients who received heparin in hospital only with 168 patients who received daily postoperative enoxaparin until day 28 after discharge, and found a reduction from 12% to 5%.

Surprisingly, despite a large number of patients on extended prophylaxis (352), we did not find a reduction

in VTE events in our cohort. A prior study from our institution has similarly shown that extended duration VTE prophylaxis regimens have not decreased the rate of VTE [6]. Given that this is a retrospective analysis a few comments can be made. It is likely that there is some sample bias; the majority of cases for which prophylaxis information was missing were from the two earlier time periods, and complication data collection has been most thorough in the most recent period. Perhaps using LMWH throughout the postoperative period as the Pariser group did would have led to a decreased rate of VTE. In light of level I evidence supporting the use of extended prophylaxis after major abdominopelvic surgery and consistent reports that the majority of symptomatic VTE are found after discharge (as we also found), we continue to believe in the importance of extended LMWH and it is our standard practice after RC. It is a limitation of our study that we did not have extensively detailed information regarding anticoagulation regimen for each individual patient, and were, therefore, unable to run analysis on patients who had extended prophylaxis from those who did not.

Another important limitation of our study is that the rates of VTE are presumably higher than we report given that there was no screening done. In a study of 86 RC patients where screening pelvic and lower extremity Doppler ultrasound was performed at postoperative day 7, an overall VTE rate of 24% was seen of which over 60% were asymptomatic [30]. All patients with DVT found on screening were put on 3 months of therapeutic anticoagulation; none of these patients went on to develop PE. Based on our findings that non-O patients have twice the rate of VTE, screening Doppler US in these patients may be warranted. However, it should be emphasized that our patients have been diligently followed through clinical visits as well as nurse navigator phone calls in the first 90 days postoperatively to meet our high capture rate.

Given the significant perioperative morbidity of radical cystectomy, it is critical that we identify non-modifiable risk factors for adverse perioperative events such as VTE. Kim et al. analyzed all RC cases from the Nationwide Inpatient Sample and found that postoperative VTE increased median LOS by 2 days, almost doubled hospitalization costs and most disturbingly, increased in-hospital mortality by five times Kim et al, formatted as [4]. In this climate of value driven care, we must not only identify such predictors of complications and readmission, but also individualize perioperative management in high risk patients. Our data validate a prior study showing that non-O blood type is a high risk feature for postoperative VTE after RC, and supports the vigilant management of these patients, from having a lower threshold to initiating a diagnostic work-up when early symptoms present, to considering the use of screening Doppler US during the perioperative period. In terms of the latter, a cost–benefit analysis is needed to evaluate its use perioperatively.

Conclusions

Non-O blood type is a non-modifiable risk factor for VTE after radical cystectomy and carries a twofold risk in this setting. These patients should be considered high risk for thromboembolic events and comprehensive prophylaxis, prompt work-up and perhaps perioperative screening is warranted.

Author contributions SB: data management; data analysis; manuscript editing; other (critical review). KK: data collection or management; data analysis; manuscript writing/editing, STB: data collection or management; data analysis; manuscript writing/editing. GM: data collection or management; data analysis. JC: data collection or management; Data analysis. SD: protocol/project development; manuscript editing; other (critical review). HD: Protocol/project development; data management; data analysis; manuscript editing; other (critical review).

Funding None.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals 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.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. VanDlac AA, Cowan NG, Chen Y, Anderson RE, Conlin MJ, La Rochelle JC, Amling CL, Koppie TM (2014) Timing, incidence and risk factors for venous thromboembolism in patients undergoing radical cystectomy for malignancy: a case for extended duration pharmacological prophylaxis. J Urol 191(4):943–947. https://doi.org/10.1016/j.juro.2013.10.096
2. Alberts BD, Woldu SL, Weinberg AC, Danzig MR, Korets R, Badani KK (2014) Venous thromboembolism after major urologic oncology surgery: a focus on the incidence and timing of thromboembolic events after 27,455 operations. Urology 84(4):799–806. https://doi.org/10.1016/j.urology.2014.05.055
3. Agnelli G, Bolis G, Capussotti L, Scarpa RM, Tonelli F, Bonizzoni E, Moia M, Parazzini F, Rossi R, Sonaglia F, Valarani B, Bianchini C, Gussoni G (2006) A clinical outcome-based prospective study on venous thromboembolism after cancer surgery: the @RISTOS project. Ann Surg 243(1):89–95
4. Kim SP, Shah ND, Karnes RJ, Weight CJ, Frank I, Moriarty JP, Han LC, Borah B, Tollefson MK, Boorjian SA (2012) The implications of hospital acquired adverse events on mortality, length of

stay and costs for patients undergoing radical cystectomy for bladder cancer. J Urol 187(6):2011–2017. https://doi.org/10.1016/j.juro.2012.01.077
5. Culkin DJ, Exaire EJ, Green D, Soloway MS, Gross AJ, Desai MR, White JR, Lightner DJ (2014) Anticoagulation and antiplatelet therapy in urological practice: ICUD/AUA review paper. J Urol 192(4):1026–1034. https://doi.org/10.1016/j.juro.2014.04.103
6. Sun AJ, Djaladat H, Schuckman A, Miranda G, Cai J, Daneshmand S (2015) Venous thromboembolism following radical cystectomy: significant predictors, comparison of different anticoagulants and timing of events. J Urol 193(2):565–569. https://doi.org/10.1016/j.juro.2014.08.085
7. Duivenvoorden WC, Daneshmand S, Canter D, Lotan Y, Black PC, Abdi H, van Rhijn BW, Fransen van de Putte EE, Zareba P, Koskinen I, Kassouf W, Traboulsi SL, Kukreja JE, Boström PJ, Shayegan B, Pinthus JH (2016) Incidence, characteristics and implications of thromboembolic events in patients with muscle invasive urothelial carcinoma of the bladder undergoing neoadjuvant chemotherapy. J Urol 196(6):1627–1633. https://doi.org/10.1016/j.juro.2016.06.017
8. Tollefson MK, Karnes RJ, Rangel L, Carlson R, Boorjian SA (2014) Blood type, lymphadenectomy and blood transfusion predict venous thromboembolic events following radical prostatectomy with pelvic lymphadenectomy. J Urol 191(3):646–651. https://doi.org/10.1016/j.juro.2013.10.062
9. Wang JK, Boorjian SA, Frank I, Tarrell RF, Thapa P, Jacob EK, Tauscher CD, Tollefson MK (2014) Non-O blood type is associated with an increased risk of venous thromboembolism after radical cystectomy. Urology 83(1):140–145. https://doi.org/10.1016/j.urology.2013.08.046
10. Stein JP, Skinner DG (2004) Surgical atlas. Radical cystectomy. BJU Int 94(1):197–221. https://doi.org/10.1111/j.1464-410X.2004.04981.x
11. Morelli VM, de Visser MC, van Tilburg NH, Vos HL, Eikenboom JC, Rosendaal FR, Bertina RM (2007) ABO blood group genotypes, plasma von Willebrand factor levels and loading of von Willebrand factor with A and B antigens. Thromb Haemost 97(4):534–541
12. Brill A, Fuchs TA, Chauhan AK, Yang JJ, De Meyer SF, Köllnberger M, Wakefield TW, Lämmle B, Massberg S, Wagner DD (2011) von Willebrand factor-mediated platelet adhesion is critical for deep vein thrombosis in mouse models. Blood 117(4):1400–1407. https://doi.org/10.1182/blood-2010-05-287623
13. Jenkins PV, O'Donnell JS (2006) ABO blood group determines plasma von Willebrand factor levels: a biologic function after all? Transfusion 46(10):1836–1844. https://doi.org/10.1111/j.1537-2995.2006.00975.x
14. Gallinaro L, Cattini MG, Sztukowska M, Padrini R, Sartorello F, Pontara E, Bertomoro A, Daidone V, Pagnan A, Casonato A (2008) A shorter von Willebrand factor survival in O blood group subjects explains how ABO determinants influence plasma von Willebrand factor. Blood 111(7):3540–3545. https://doi.org/10.1182/blood-2007-11-122945
15. Nossent AY, van Marion V, van Tilburg NH, Rosendaal FR, Bertina RM, van Mourik JA, Eikenboom HC (2006) von Willebrand factor and its propeptide: the influence of secretion and clearance on protein levels and the risk of venous thrombosis. J Thromb Haemost 4(12):2556–2562. https://doi.org/10.1111/j.1538-7836.2006.02273.x
16. Bowen DJ (2003) An influence of ABO blood group on the rate of proteolysis of von Willebrand factor by ADAMTS13. J Thromb Haemost 1(1):33–40
17. Matsui T, Titani K, Mizuochi T (1992) Structures of the asparagine-linked oligosaccharide chains of human von Willebrand factor. Occurrence of blood group A, B, and H(O) structures. J Biol Chem 267(13):8723–8731
18. Dentali F, Sironi AP, Ageno W, Turato S, Bonfanti C, Frattini F, Crestani S, Franchini M (2012) Non-O blood type is the commonest genetic risk factor for VTE: results from a meta-analysis of the literature. Semin Thromb Hemost 38(5):535–548. https://doi.org/10.1055/s-0032-1315758
19. De Martino RR, Goodney PP, Spangler EL, Wallaert JB, Corriere MA, Rzucidlo EM, Walsh DB, Stone DH (2012) Variation in thromboembolic complications among patients undergoing commonly performed cancer operations. J Vasc Surg. 55(4):1035–1040.e1034. https://doi.org/10.1016/j.jvs.2011.10.129
20. Mehrazin R, Piotrowski Z, Egleston B, Parker D, Tomaszweski JJ, Smaldone MC, Abbosh PH, Ito T, Bloch P, Iffrig K, Bilusic M, Chen DY, Viterbo R, Greenberg RE, Uzzo RG, Kutikov A (2014) Is extended pharmacologic venous thromboembolism prophylaxis uniformly safe after radical cystectomy? Urology 84(5):1152–1156. https://doi.org/10.1016/j.urology.2014.06.058
21. Violette PD, Cartwright R, Briel M, Tikkinen KA, Guyatt GH (2016) Guideline of guidelines: thromboprophylaxis for urological surgery. BJU Int 118(3):351–358. https://doi.org/10.1111/bju.13496
22. Tikkinen KA, Craigie S, Agarwal A, Violette PD, Novara G, Cartwright R, Naspro R, Siemieniuk RA, Ali B, Eryuzlu L, Geraci J, Winkup J, Yoo D, Gould MK, Sandset PM, Guyatt GH (2017) Procedure-specific risks of thrombosis and bleeding in urological cancer surgery: systematic review and meta-analysis. Eur Urol. https://doi.org/10.1016/j.eururo.2017.03.008
23. Rasmussen MS, Jørgensen LN, Wille-Jørgensen P (2009) Prolonged thromboprophylaxis with low molecular weight heparin for abdominal or pelvic surgery. Cochrane Database Syst Rev. 1:CD004318. https://doi.org/10.1002/14651858.cd004318.pub2
24. Seng S, Liu Z, Chiu SK, Proverbs-Singh T, Sonpavde G, Choueiri TK, Tsao CK, Yu M, Hahn NM, Oh WK, Galsky MD (2012) Risk of venous thromboembolism in patients with cancer treated with Cisplatin: a systematic review and meta-analysis. J Clin Oncol 30(35):4416–4426. https://doi.org/10.1200/JCO.2012.42.4358
25. Gershman B, Moreira DM, Tollefson MK, Frank I, Cheville JC, Thapa P, Tarrell RF, Thompson RH, Boorjian SA (2016) The association of ABO blood type with disease recurrence and mortality among patients with urothelial carcinoma of the bladder undergoing radical cystectomy. Urol Oncol 34(1):4.e1-9. https://doi.org/10.1016/j.urolonc.2015.07.023
26. Klatte T, Xylinas E, Rieken M, Rouprêt M, Fajkovic H, Seitz C, Karakiewicz PI, Lotan Y, Babjuk M, de Martino M, Shariat SF (2014) Effect of ABO blood type on mortality in patients with urothelial carcinoma of the bladder treated with radical cystectomy. Urol Oncol 32(5):625–630. https://doi.org/10.1016/j.urolonc.2013.11.010
27. Süer E, Özcan C, Gökçe I, Gülpınar Ö, Göğüş C, Türkölmez K, Baltacı S, Bedük Y (2014) Do blood groups have effect on prognosis of patients undergoing radical cystectomy? Int Urol Nephrol 46(8):1521–1526. https://doi.org/10.1007/s11255-014-0698-x
28. Bergqvist D, Agnelli G, Cohen AT, Eldor A, Nilsson PE, Le Moigne-Amrani A, Dietrich-Neto F, Investigators EI (2002) Duration of prophylaxis against venous thromboembolism with enoxaparin after surgery for cancer. N Engl J Med 346(13):975–980. https://doi.org/10.1056/NEJMoa012385
29. Pariser JJ, Pearce SM, Anderson BB, Packiam VT, Prachand VN, Smith ND, Steinberg GD (2017) Extended duration enoxaparin decreases the rate of venous thromboembolic events after radical cystectomy compared to inpatient only subcutaneous heparin. J Urol 197(2):302–307. https://doi.org/10.1016/j.juro.2016.08.090
30. Clément C, Rossi P, Aissi K, Barthelemy P, Guibert N, Auquier P, Ragni E, Rossi D, Frances Y, Bastide C (2011) Incidence, risk profile and morphological pattern of lower extremity venous thromboembolism after urological cancer surgery. J Urol 186(6):2293–2297. https://doi.org/10.1016/j.juro.2011.07.074