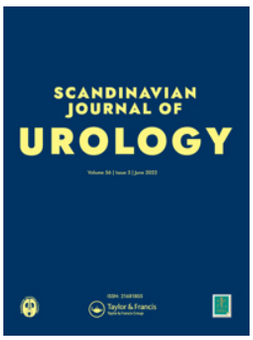

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ARTICLE

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# Intraoperative complications in kidney tumor surgery: critical grading for the European Association of Urology intraoperative adverse incident classification

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**ABSTRACT**

**Introduction:** The European Association of Urology committee in 2020 suggested a new classification, intraoperative adverse incident classification (EAUiaiC), to grade intraoperative adverse events (IAE) in urology.

**Aims:** We applied and validated EAUiaiC, for kidney tumor surgery.

**Patients and methods:** A retrospective multicenter study was conducted based on chart review. The study group comprised 749 radical nephrectomies (RN) and 531 partial nephrectomies (PN) performed in 12 hospitals in Finland during 2016–2017. All IAEs were centrally graded for EAUiaiC. The classification was adapted to kidney tumor surgery by the inclusion of global bleeding as a transfusion of $\geq$3 units of blood (Grade 2) or as $\geq$5 units (Grade 3), and also by the exclusion of preemptive conversions.

**Results:** A total of 110 IAEs were recorded in 13.8% of patients undergoing RN, and 40 IAEs in 6.4% of patients with PN. Overall, bleeding injuries in major vessels, unspecified origin and parenchymal organs accounted for 29.3, 24.0, and 16.0% of all IEAs, respectively. Bowel ($n = 10$) and ureter ($n = 3$) injuries were rare. There was no intraoperative mortality. IAEs were associated with increased tumor size, tumor extent, age, comorbidity scores, surgical approach and indication, postoperative Clavien–Dindo (CD) complications and longer stay in hospital. 48% of conversions were reactive with more CD-complications after reactive than preemptive conversion (43 vs. 25%).

**Conclusions:** The associations between IAEs and preoperative variables and postoperative outcome indicate good construct validity for EAUiaiC. Bleeding is the most important IAE in kidney tumor surgery and the inclusion of transfusions could provide increased objectivity.

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Kidney tumor; renal cell carcinoma; intraoperative complications; intraoperative adverse events; perioperative outcome; EAUiaiC

## Introduction

An intraoperative adverse event (IAE) is defined as an undesired event due to surgical intervention occurring between the incision and the closure of the skin [1]. In 2002, Satava et al. [2] suggested a simple system to evaluate intraoperative surgical errors in otolaryngology. This system was further elaborated to a three-grade classification of intraoperative incidents in surgery [3]. The Intraoperative Adverse Events Classification Scheme used in Massachusetts General Hospital was reported in 2014 by Kaafarani et al. [4]. The third classification, called Definition and Classification of Intraoperative Complications (CLASSIC) was launched in 2015 in Basel [5]. Unfortunately, none of these classifications has become popular in urology. The Clavien–Dindo (CD) classification of surgical complications has however gained an established position in urology [6,7], but it is based only on the treatment given after the operation.

In a systematic review on robotic partial nephrectomy, Cacciamani et al. [8] found that IAEs were included only in 50% of the studies on the perioperative outcome and none of them included any grading of severity. Consequently, a standardized classification of IAEs in urology is still lacking and represents a significant challenge to perioperative outcome reporting.

In 2019, the European Association of Urology ad hoc Complications Guidelines Panel proposed a novel system, called EAU intraoperative adverse incident classification (EAUiaiC) [1]. Until now, only a few reports using the system

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have been published in urology research [9–11]. In general, the criteria of EAUiaiC are well accepted but validations in urological subspecialities are still forthcoming.

Kidney tumor surgery covers a large range of anatomical variations and surgical challenges. Advanced tumors with neo-vascularization and contacts with adjacent organs predispose to bleedings and injuries in the adjacent organs. In the present report, we describe IAEs in a large group of patients who underwent kidney tumor surgery, and we grade IAEs for the EAUiaiC. We also critically evaluate the validity of the classification against preoperative predictors of IAEs and postoperative complications.

## Patients and methods

### Study design

A retrospective observational multicenter study was performed by the FinnKidney study group. The study was approved by the ethics committee of Helsinki and Uusimaa Hospital District (HUS) and by the institutional review boards of all participating centers.

### Study group

We searched the FinnKidney database that had been originally collected for a national surgical quality project, to identify patients who had undergone active urological treatment for radiographically defined kidney tumors suspected for renal cell carcinoma in five university hospitals and seven nonuniversity public hospitals in Finland between 1 January 2016 and 31 December 2017. The study group comprised 1280 patients who underwent kidney tumor excision and who had sufficient available data to evaluate perioperative outcome.

### Data collected

Data were originally collected retrospectively by reviewing patients' charts by site primary investigators (urologists). For the present study, the following data were extracted and analyzed: BMI, Eastern Cooperative Oncology Group performance status (ECOG), Charlson comorbidity index (CCI) according to Quan et al. [12], American Society of Anesthesiology (ASA), renal tumor size (cm), R.E.N.A.L. nephrometry score [13] for tumors planned for PN, nephrectomy type (PN, RN), surgical approach (open, minimally-invasive laparoscopy including traditional, hand-port and robot-assisted), presence of intravenous tumor thrombus by the Mayo Clinic classification [14]. Intraoperative complications were primarily recorded (no/yes) and when 'yes', the predefined organ system and type of the complication were obtained. Investigators were asked to describe the complications in free text. Postoperative CD-complications of the cohort were previously reported [15] and were used in this study to validate the modified EAUiaiC.

### Grading of intraoperative adverse events for EAUiaiC

The grading was elaborated by a FinnKidney working group in line with the original EAU committee suggestions [1], previous classifications for IAEs [4] and some recent reports using EAUiaiC [9,10].

One patient may have several IAEs. To evaluate the impact of more than one IAE for a patient, only the IAE with the highest grade was used. The grade of IAE was based on the treatment given and information available at the end of the operation [5]. The important components of IAEs in kidney tumor surgery are bleeding, adjacent parenchymal organ lesions, bowel and ureter lesions and conversions.

Global bleeding is defined as the number of transfused units of packed red blood cells (PRBC). Vessel ligation, suturing and clips to control bleeding in major vessels [inferior vena cava (IVC), aorta and renal arteries and veins, or some other specified major vessel] were initially graded 2, but upgraded to 3 whenever any transfusion of PRBC was required during the operation. Global bleeding from small vessels, unspecified origin and parenchymal organs were graded 0, unless a significant global bleeding was present, as defined by a transfusion of 3−4 units of PRBC (grade 2) and also as a massive bleeding, defined by a transfusion of $\geq$5 units (grade 3) [16,17]. Transfusions to correct preoperative anemia were excluded. Hemostatic agents laid on parenchymal organs to stop bleeding were graded 1 [10]. An opening of the urinary tract, bowel, pleura or diaphragm requiring suturing during operation were graded 2. Ischemic and functional losses of kidney and adjacent organs were estimated for EAUiaiC only in terms of total or partial removal of the organ as grade 4.

Tumor incisions were graded only when they caused tumor spillage or conversions or other changes in surgical performance. Corrections of resection line due to suspect small incision of tumor were not considered. The complication grade for the adrenals was assigned as 4 A, whenever a total adrenalectomy was required. Less severe adrenal and vessel injuries were assessed by possible global bleeding.

Conversions from PN to RN and from minimally invasive to open surgery were recorded as reactive when they were caused by intraoperative complications such as bleeding or bowel injury. In contrast, conversions were considered as preemptive and not IAEs, when they were caused by unclear anatomy, oncological situation or adhesions as per Cleveland Clinic practice [18]. In PN, a conversion was always labeled as reactive when the resection had started before the decision to convert. Nephrectomy type and surgical approach were recorded as planned for reactive conversions and as actual for preemptive conversions.

### Statistical analysis

RN and PN groups were analyzed separately. Median with interquartile range (IQR) and mean with standard deviation (SD) were used to describe quantitative parameters and distributions, whereas numbers and percentage were used for qualitative parameters. Differences between groups were

tested by the Chi square test for categorical and with the Kruskal–Wallis test and the Student's *t*-test for continuous variables.

Preoperative predictors for IAEs were determined by multivariable logistic regression with the conditional backward selection method and probability for stepwise removal of 0.10. To evaluate the construct validity of the classification, the presence of IAEs was correlated to the occurrence of CD grade 2−5 postoperative complications and length of hospital stay (LOS). SPSS (version 25, IBM, Armonk, NY, USA) was used for statistical calculations. All tests were two-sided, with $p < 0.05$ considered to be statistically significant.

## Results

The study group consisted of 749 patients who underwent RN and 531 PN. The clinical characteristics of RN and PN are seen in Table 1. Overall, 110 IAEs were recorded for 103 patients (13.8%) undergoing RN, and 40 IAEs were recorded for 34 patients (6.4%) with PN. All IAEs with severity grades are shown in Table 2. Bleeding injuries in major vessels and unspecified origin were significantly more frequent during RN (9.0%, 67/749) compared to PN (2.5%, 13/531; $p < 0.001$). Additionally, 12 spleen injuries (grade 1, $n = 10$; grade 4 A, $n = 2$), eight liver injuries (grade 1, $n = 6$; grade 3, $n = 2$) and four renal fossa bleedings (grade 3, $n = 2$; grade 4 A, $n = 2$) were recorded. Bowel ($n = 10$) and ureter ($n = 3$) injuries were rare. There were no intraoperative deaths.

All conversions from PN to RN were 4.0% (21/531) and from minimally invasive to open surgery 6.9% (41/591). The percentage of reactive conversions from PN to RN was 57.1% (12/21) and from minimally invasive to open surgery 43.9% (18/41). Table 3 compares intraoperative morbidity between PN and RN. Rates of severe (grade 3−5) and nonsevere (grade 1−2) morbidity caused by IAEs were statistically greater in patients with RN compared to PN.

### *Preoperative variables and IAEs*

Table 4 shows the multivariable logistic regression analyses of preoperative variables to predict the presence of any IAE. Independent preoperative predictors for IAEs for RN were ASA 3−4, increased size of tumor, open surgical approach, cytoreductive operation and Mayo level 1−4 venous thrombus. Independent predictors for IAEs for PN were increased size of tumor, older age and CCI.

Combinations of some risk factors was shown to induce very high risks of IAEs. First, tumor size ≥7cm combined with IVC tumor thrombus level 1−4, which was recorded in 36 patients, was associated with any grade (1−5) and high grade (3−5) IAEs in 61.1% (22/36) and 41.7% (15/36), respectively. In these patients, any, ≥3 and ≥5 transfusions of PRBCs were given in 80.6% (29/36), 58.3% (21/36) and 38.9% (14/36) of patients, respectively. The median (IQR) for estimated blood loss (EBL) was 2000 (1300−3500) ml.

Second, a tumor size ≥7 cm combined with a cytoreductive indication, which was recorded in 97 patients, was associated with any grade (1−5) and high grade (3−5) IAEs in 29.9% (29/97) and 20.6% (20/97), respectively. Transfusions of any, ≥3 and ≥5 units of PRBCs were given in 42.2% (41/97), 17.5% (17/97) and 13.4% (13/97) of these patients, respectively. The median (IQR) for EBL was 770 (300−1900) ml.

### *Validity of EAUiaiC*

The presence of postoperative CD-complications grade 2−5 and LOS were assessed against the presence of any IAEs, the results are presented in Table 5. There was a significant association between IAEs and CD-complications for RN. The rate of CD-complications was also higher in patients with EAUiaiC grades 3−5 compared to those with grades 1−2, but the difference was not statistically significant (40.4 vs. 30.4%, $p = 0.297$). Patients with EAUiaiC grades 3−5 also had a longer mean (SD) LOS compared to those with grades 1−2 [8.0 (5.5) vs. 5.0 (2.5) days; $p < 0.001$]. In PN, CD-complications were significantly associated with the presence of any IAEs ($p = 0.023$) but there was no difference between patients with grades 3−5 vs. 1−2. In addition, CD-complications were more frequent after reactive than preemptive conversions [43.3% (13/30) vs. 25.0% (8/32), $p = 0.127$], but the difference was not statistically significant.

## Discussion

The present study provides a representative insight into the type of IAEs during RN and PN performed in patients with radiologically defined kidney tumors suspect for renal cell carcinoma. A total of 150 IAEs were identified and graded using the classification developed by the EAU committee. Based on this experience and regarding the special features of kidney tumor surgery, we decided to propose two small refinements concerning global blood transfusion, and conversions.

Bleeding is a frequent IAE in kidney tumor surgery and EBL is a strong predictor of postoperative complications [19]. In the present group, bleeding injuries accounted for 53.3% of all IAEs and for 29.3% when global bleedings outside the major vessels were ignored. The first value is in line with a recent meta-analysis of 29,227 robotic PNs where bleeding was reported to account for 58% of all IAEs [8]. The second value is in line with the 30.2% obtained using the EAUiaiC in selected patients undergoing urinary upper-tract robotic surgery reported recently by Fernandez-Pello et al. [10].

During any surgical operations, bleeding injuries are managed with operative steps such as suturing, clips, hemostatic agents, anesthesiological measures when needed and may also include transfusions of blood products. The European Society of Anesthesiology recommends transfusions to be started when hemoglobin concentration of 7–9 g/dl occur during active bleeding [20]. Logically, when stratified to the risk of bleeding, the amount of blood transfused can inversely reflect the quality of the surgical performance.

The current grading of IAE for EAUiaiC is based solely on surgical interventions [1]. This information alone, may in some cases, result in misleading gradings. For example, an

Table 1. Clinical characteristics.

| | Radical nephrectomy ($n = 749$) | Partial nephrectomy ($n = 531$) | |
|---|---|---|---|
| Variable | N(%) | N(%) | $p$-Value* |
| Sex | | | |
| Male | 418 (55.8) | 345 (65.0) | |
| Female | 331 (44.2) | 186 (35.0) | <0.001 |
| Age, median (IQR) | 68 (60–75) | 66 (57–72) | <0.001 |
| BMI, median (IQR) | 26.7 (24.0–30.7) | 27.8 (25.9–31.0) | 0.009 |
| Missing | 2 (0.3) | 3 (0.6) | |
| CCI | | | |
| 0 | 469 (62.6) | 311 (58.6) | |
| 1 | 105 (14.0) | 70 (13.2) | |
| ≥2 | 175 (23.4) | 150 (28.2) | 0.048 |
| ECOG | | | |
| 0–1 | 596 (79.6) | 455 (85.7) | |
| ≥2 | 122 (16.3) | 50 (9.4) | <0.001 |
| Missing | 31 (4.1) | 26 (4.9) | |
| ASA | | | |
| 1–2 | 329 (43.9) | 261 (49.2) | |
| 3–4 | 420 (56.1) | 270 (50.8) | 0.065 |
| Size of tumor, cm , median (IQR) | 7.0 (5.0–9.5) | 3.0 (2.2–3.8) | <0.001 |
| Missing | 10 (1.3) | 0 (0.0) | |
| R.E.N.A.L. Nephromery Score | | | |
| 4–6 | | 241 (45.4) | |
| 7–9 | | 245 (46.1) | |
| 10–11 | | 25 (4.7) | |
| Missing | | 20 (3.8) | |
| Surgical approach | | | |
| Open | 348 (46.5) | 241 (45.4) | |
| Laparoscopy | 371 (49.5) | 126 (23.7) | |
| Hand-assisted | 29 (3.9) | 39 (7.3) | |
| Robot-assisted | 1 (0.1) | 125 (23.5) | 0.704 |
| NSS indication | | | |
| Elective | | 512 (96.4) | |
| Imperative | | 19 (3.6) | |
| Intravenous tumor thrombus, Mayo classification | | | |
| No venous invasion | 651 (86.9) | | |
| Level 0 | 54 (7.2) | | |
| Level 1 | 14 (1.9) | | |
| Level 2 | 25 (3.3) | | |
| Level 3 | 3 (0.4) | | |
| Level 4 | 2 (0.3) | | |
| Lymhadenectomy | | | |
| Yes | 71 (9.5) | 5 (0.9) | |
| No | 678 (90.5) | 526 (99.1) | 0.001 |
| Pathological classification | | | |
| Malignant | 689 (92.0) | 433 (81.5) | |
| Benign | 59 (7.9) | 98 (18.5) | <0.001 |
| Missing | 1 (0.1) | 0 (0.0) | |
| Metastatic | | | |
| M0 benign | 59 (7.9) | 98 (18.5) | |
| M0 | 551 (73.6) | 426 (80.2) | |
| M1 | 135 (18.0) | 7 (1.3) | <0.001 |
| Missing | 4 (0.5) | 0 (0.0) | |
| Lymphnodes | | | |
| Benign Kidney tumor | 59 (7.9) | 98 (18.5) | |
| pNX/pN0 | 644 (86,0) | 431 (81.2) | |
| pN1 | 42 (5.6) | 1 (0.2) | <0.001 |
| Missing | 4 (0.5) | 1 (0.2) | |
| EBL median (IQR, ml | 200 (50–630) | 200 (100–465) | 0.896 |
| Missing | 4 (0.5) | 3 (0.6) | |
| Blood transfusion, number of PRBCs during operation, n (%) | | | |
| 0 | 622 (83.0) | 500 (94.2) | |
| 1–2 | 77 (10.3) | 25 (4.7) | |
| 3–4 | 22 (2.9) | 3 (0.6) | |
| ≥5 | 27 (3.6) | 3 (0.6) | |

*Statistical tests were performed between categories CCI 0–1/≥2, ECOG 0–1/2–4, ASA 1–2/3–4, open/minimally-invasive, pN1/pN0-X. Differences between medians were tested with Kruskal–Wallis and between means with t-test. Categorized values were test with Chi square test.
CCI: Charlson comorbidity index; IQR: inter quartile range; ECOG: Eastern Cooperative Oncology Group performance status; NSS: nephron sparing indication; EBL: estimated blood loss; PRBS: packed red blood cells.

IAE consisting of a 5 mm tear the IVC treated with suturing may indicate a small number of sutures by a qualified surgeon or a prolonged suturing by a nonexperienced surgeon eventually leading to a hemodynamic imbalance and blood transfusions. These two scenarios may be equally graded for EAUiaiC (grade 3), but they are highly different from the perspective of a patient for safety and surgical quality. Moreover, we wonder which is the more severe: a significant

Table 2. Intraoperative adverse events and treatment graded for EAUiaiC.

| Radical nephrectomy ($N = 749$) | | Partial nephrectomy ($N = 531$) | |
|---|---|---|---|
| Event/Treatment (grade) | N | Event/Treatment (grade) | N |
| Inadvertant ligation of renal artery in the opposite side/removal of the clamp (5A) | 1 | Inadvertant ligation of a renal arterial branch/Ischemic injury comparable to partial nephrectomy (4A) | 1 |
| Diaphragm injury/suturation (2) | 5 | Kidney injury/hemostatic agents (1) | 2 |
| Diaphragm injury/suturation, conversion lap open (4B) | 1 | Urine leakage from resection fossa/conversion partial radical (4A) | 1 |
| Pleura injury/suturation (2) | 6 | Tumor rupture and spillage/resection of fatty tissue around (2) | 1 |
| Spleen injury/hemostatic agents (1) | 10 | Oncological assessment changed during resection/conversion partial radical (4A) | 3 |
| Spleen injury/splenectomy (4A) | 2 | Tumor incision during resection/conversion partial radical (4A) | 2 |
| Renal pedicle bleeding/hemostasis (2) | 1 | Resection of false part of kidney/new operation (5A) | 1 |
| Renal pedicle bleeding/hemostasis, blood (3) | 6 | Renal fossa bleeding/suturing blood (3) | 2 |
| Renal pedicle bleeding/hemostasis, hand-port (3) | 2 | Renal fossa bleeding/suturing, conversion lap open (4B) | 2 |
| Renal pedicle bleeding/hemostasis, conversion lap open (4B) | 3 | Pleura injury/suturation (2) | 3 |
| Renal vein with tumor thrombus resected incompletely/re-resection, blood (3) | 1 | Renal pedicle bleeding/hemostasis (2) | 1 |
| IVC injury/suturing, no blood (2) | 2 | Renal pedicle bleeding/hemostasis, hand-port (3) | 1 |
| IVC injury/suturing, blood (3) | 9 | Renal pedicle bleeding/conversion partial radical (4A) | 4 |
| IVC injury/suturing, conversion lap open (4B) | 3 | Renal pedicle bleeding/hemostasis, conversion lap open (4B) | 1 |
| Renal artery bleeding/ligation, blood (3) | 1 | IVC injury/suturing, no blood (2) | 2 |
| Renal artery bleeding/ligation, conversion lap open (4B) | 1 | IVC injury/suturing, blood (3) | 1 |
| Renal artery bleeding, Hemolock opened/Ligation, conversion lap open (4B) | 1 | Vena llienalis injury/suturing, blood (3) | 1 |
| Lumbal artery bleeding/suturing, blood (2) | 1 | Bleeding unspecified origin/hemostasis, blood (2) | 2 |
| Collateral veins bleeding/hemostasis, blood (3) | 2 | Liver injury/hemostatic agents (1) | 1 |
| Bleeding unspecified origin/hemostasis, blood (2) | 16 | Colon injury/suturing (2) | 1 |
| Bleeding unspecified origin/hemostasis, blood (3) | 14 | Small bowel injury | 1 |
| Bleeding unspecified origin/hemostasis, conversion lap open (4B) | 4 | Ureter injury/suturing (2) | 3 |
| Liver injury/hemostatic agents (1) | 5 | Hypotonia anafylaxia/conversion partial radical (4A) | 1 |
| Liver injury/suturing, blood transfusions (3) | 2 | Embolia pulmonis hypotonia/conversion partial radical (4A) | 1 |
| Colon injury/suturing (2) | 2 | Gallbladder injury retractor/removal of gallbladder (4A) | 1 |
| Colon injury/suturation, conversion lap open (4B) | 1 | | |
| Small bowel injury/suturing (2) | 2 | | |
| Small bowel injury/suturing, conversion lap open (4B) | 1 | | |
| Duodenal injury/suturing (2) | 2 | | |
| Adrenal injury bleeding/suturing, blood (2) | 1 | | |
| Adrenal injury bleeding/adrenalectomy (4A) | 1 | | |
| Breakdown of the removal bag/enlargement of the wound (2) | 1 | | |

Grade 0: Event requiring no intervention or change in operative approach, no deviation from planned intraoperative steps, no consequence for the patient = no complication.
Grade 1: Event requiring additional/alternative procedure in planned intraoperative steps, not life-threatening or involving part or full organ removal. The event was addressed in a controlled manner with no long-term side effects.
Grade 2: Event requiring major additional/alternative procedure in operative approach but NOT immediately life-threatening. The event was addressed in a controlled manner, however, may have short- or long-term side effects.
Grade 3: Event requiring major additional/alternative procedure in addition to planned intraoperative steps and incident becoming immediately life- threatening but NOT requiring part or full organ removal; may have short- or long-term side effects.
Grade 4: Event requiring major additional/alternative procedure in addition to planned intraoperative steps becoming immediately life-threatening and with short- or long-term consequences to patient.
Grade 4A: Requiring part or full organ removal.
Grade 4B: Unable to complete planned procedure as planned due to a technical issue or surgical event and/or required unplanned stoma (change in body image, e.g. stoma, major skin flap).
Grade 5A: Wrong site or side for ablative surgery or removal of an organ or wrong patient or no consent.
Grade 5B: Intraoperative death.
EAUiciC: EAU intraoperative incidents grading classification; IVC: inferior vena cava.

bleeding from many minor vessels treated with hemostasis and transfusions (grade 0) or a small tear in the spleen capsule requiring a small hemostatic agent and no transfusions (grade 1).

Any classification of IAE must be clinically significant, valid and consistent in order to gain acceptance among surgeons. EBL and blood transfusions have for a long time been included as additional information in perioperative complication reporting [4,16,19,21,22]. This kind of information is also easily and objectively retrieved in retrospective chart review. The modified Satava classification [3] entails the concept 'blood loss which is appreciably above the normal range'. Moreover, the inclusion of blood transfusions into the grading of IAEs may also be supported in a report showing worse oncological outcome in patients having transfusions during the operation [23]. Transfusions could be a valuable part of IAEs, especially in areas where bleeding injuries are frequent.

All conversions are labelled as IAEs in the current EAUiaiC. This practice can be justified objectively. However, the reason to convert may be due to a complication (reactive to an IAE) or an effort to prevent one (preemptive). An example of a preemptive conversion could be one where a surgeon faces a right-sided upper pole tumor that is adherent or suspected to be invasive into the liver and the surgeon then decides to convert to open surgery. In one study on radical cystectomy, intraoperative conversions from the neobladder to conduit were more common because of oncological reasons than technical reasons (58.3 vs 35.9%) [24]. In another

Table 3. Patients undergoing kidney tumor surgery graded for the presence of intraoperative adverse events according to EAUiaiC (the highest grade).

| | Radical nephrectomy ($n = 749$) | Partial nephrectomy ($n = 531$) | |
|---|---|---|---|
| Grade | *N* (%) | *N* (%) | $p^*$ |
| No IAE (Grade 0) | 646 (86.2) | 497 (93.6) | |
| Grade 1 | 11 (1.5) | 1 (0.2) | |
| Grade 2 | 35 (4.7) | 12 (2.3) | |
| Grade 3 | 38 (5.1) | 5 (0.9) | |
| Grade 4A | 3 (0.4) | 12 (2.3) | |
| Grade 4B | 15 (2.0) | 3 (0.6) | |
| Grade 5A | 1 (0.1) | 1 (0.2) | |
| Grade 5B | 0 (0.0) | 0 (0.0) | |
| IAEs Grades 1–2 | 46 (6.1) | 13 (2.4) | 0.002 |
| IAEs Grades 3–5 | 57 (7.6) | 21 (4.0) | 0.007 |
| Any IAEs | 103 (13.8) | 34 (6.4) | <0.001 |

*Chi square test.
EAUiaiC: EAU intraoperative adverse incident classification; IAE: intraoperative adverse event.

Table 4. Multivariable logistic regsession analyses on preoperative variables to predict any intraoperative adverse events for EAUiaiC in patients undergoing kidney tumor surgery.

| Variable | Categories | | OR | 95%CI | *p* |
|---|---|---|---|---|---|
| A) Partial nephrectomy | | | | | |
| Size of tumor | cm | | 1.30 | 1.07–1.59 | 0.009 |
| Age | Year | | 1.05 | 1.01–1.09 | 0.011 |
| CCI | 0–1 | Ref. | 1.0 | | |
| | >=2 | | 2.13 | 1.03–4.42 | 0.041 |
| B) Radical nephrectomy | | | | | |
| ASA | 1–2 | Ref. | 1.0 | | |
| | 3–4 | | 1.78 | 1.10–2.89 | 0.021 |
| Size of tumor | cm | | 1.14 | 1.07–1.22 | <0.001 |
| Surgical approach | Open | Ref. | 1.0 | | |
| | Minimally invasive | | 0.38 | 0.21–0.67 | 0.001 |
| Intravenous tumor | No or renal vein | Ref. | 1.0 | | |
| | IVC levels 1–4 | | 4.17 | 2.10–8.30 | <0.001 |
| Cytoreductive indication | No | Ref. | 1.0 | | |
| | Yes | | 1.78 | 1.07–2.95 | 0.026 |

The variables included in the analyses were surgical approach, size of tumor, lymphadenectomy, sex, age, BMI, Charlson comorbidity index, ASA, Eastern Cooperative Oncology Group performance status, R.E.N.A.L. score (only for PN), nephron sparing indication (elective/imperative, only for PN), intravenous tumor (only RN), cytoreductive indication.
IVC: inferior vena cava; ASA: American Society Anaesthesiology classification; CCI: Charlson Comorbidity Index; EAUiaiC: EAU intraoperative adverse incident classification.

Table 5. Postoperative outcome as 90-day Clavien–Dindo complications (CDC) grade 2–5 and length of stay (LOS) correlated to the presence of any intraoperative adverse events according to the modified EAUiaiC.

| Radical nephrectomy ($n = 749$) | | | | |
|---|---|---|---|---|
| | EAUiaiC | | | |
| Variable | Grade 0 | Grade 1–2 | Grade 3–5 | $p^*$ |
| CDC 2–5 *N* (%) | 125/646 (19.3) | 14/46 (30.4) | 23/57 (40.4) | <0.001 |
| LOS, days, mean (SD) | 5.0 (2.5) | 6.6 (2.9) | 8.0 (5.5) | <0.001 |
| **Partial nephrectomy ($N = 531$)** | | | | |
| | EAUiaiC | | | |
| Variable | Grade 0 | Grade 1–2 | Grade 3–5 | |
| CDC 2–5 N (%) | 142/497 (28.6) | 7/13 (53.9) | 9/21 (42.9) | 0.023 |
| LOS, days, mean (SD) | 5.1 (2.8) | 8.7 (8.3) | 7.3 (4.7) | 0.014 |

*Chi square and t-tests were done between Grade 0 and Grade 1–5.
CDC: Clavien–Dindo classification; LOS: length of stay; EAUiaiC: European Urology Association classification of intraoperative adverse incident classification.

study from the Cleveland Clinic [18] in patients undergoing colorectal surgery, those who had reactive vs preemptive conversion to open surgery were more likely to have a postoperative complication (50 vs. 27%). This result is similar to ours and we want to highlight, along with others [18] that it is preferable for the surgeon to have a low threshold for performing conversion before, rather than after a complication arises. In this context, the current expression in EAUiaiC might give a wrong signal.

Knowledge of perioperative morbidity is essential for the counseling of patients, the stratification of comparative studies and for benchmarking [25]. The risk of IAE in kidney tumor surgery varies to a great extent on the tumor and patient characteristics [26,27]. In our data, increased size of

tumor was a common independent predictor for IAEs in RN and in PN. In addition, CCI and aging were predictors in PN, and ASA, open surgical approach, IVC tumor thrombus and cytoreductive indication in RN. These results are expected and in line with other reports [19,22]. Larger tumor size combined with cytoreductive indication or with IVC tumor thrombus leads to very high rate of intraoperative bleeding [16], an occurrence that could initiate debate over how to define grade 0 for EAUiaiC in these special groups [3]. Finally, the surgeon experience and volume have a major impact on perioperative outcome results [28]. However, surgeon-specific numbers are sensitive and we did not collect them. This kind of data should be collected prospectively, with protocol-based definitions and by independent persons.

Cacciamani and coworkers recently suggested 13 criteria to guide reporting on IAEs in 'The Intraoperative Complications Assessment and Reporting with Universal Standards (ICARUS) Global Surgical Collaboration Project' [29]. ICARUS is an ambitious macro-level guidebook for a quality improvement project in surgery. Our study could provide full data only for nine of the criteria. The criteria numbered 7, 8, and 13 call for very detailed information of single cases. The criteria 12 deals with clinical consequences of the IAEs. Although any major conflict do not exist, it could be more convenient, if the line between a postoperative complication (Clavien–Dindo) and a clinical consequence of IAE (EAIiaiC) was clarified before broader implementation of the ICARUS guidelines. After all, robust perioperative outcome reporting must include intraoperative and also postoperative adverse events [3].

Limitations of the study include the lack of including surgeons' skill and volume. We did not compare between institutions. Data are retrospective and collected by many surgeons.

In conclusion, IAEs defined by the EAUiaiC were associated with important preoperative variables and postoperative complications, thus supporting construct validity of the EAUiaiC. Exclusion of preemptive conversions from the classification and inclusion of significant global bleeding requiring transfusions are suggested.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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