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Kidney Cancer

An International Delphi Consensus About Tumor Rupture During Robotic Partial Nephrectomy (Researching UnPredictable TUmor RupturE during Robotic Partial Nephrectomy—The RUPTURE Project)

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Abstract

Background and objective: Tumor rupture during robot-assisted partial nephrectomy (RAPN) poses oncological risks, including potential malignant cell spread and recurrence. Despite these risks, standardized guidelines for defining, managing, and assessing risk factors of tumor rupture in RAPN are lacking. This Delphi consensus study aimed to frame the definition, risk factors, and oncological implications of tumor rupture in RAPN, as well as to propose management strategies.

Methods: Using a modified Delphi method, a steering committee from multiple urological societies (the RUPTURE project) led a consensus-building study that followed the ACcurate COnsensus Reporting Document (ACCORD) checklist. A panel of international experts participated in a two-phase Delphi survey, rating their agreement with statements on tumor rupture, risk factors, and management in RAPN. Consensus was defined as $\geq$70% agreement, with unresolved statements discussed in an online meeting and subjected to a second voting round.

Key findings and limitations: Thirty-three experts evaluated 58 statements. Consensus was reached on 33% of statements in the first round and 37.5% in the second round. Tumor rupture was defined, with risk factors including larger tumor size, complexity, and endophytic growth patterns. Recommended management strategies focused on minimizing tumor spillage by suctioning—rather than grasping—the cancerous tissue, and promptly securing the specimen in an endobag. Routine conversion to radical nephrectomy was not advised unless unresectable tumor remnants were found. Tumor rupture was not linked to distant metastasis, although its oncological impact varied by the rupture extent (ie, gross rupture vs focal; tumor spilled out macroscopically completely removed vs not).

Conclusions and clinical implications: This consensus forms a basis for future research on tumor rupture in RAPN, emphasizing standardized definitions and uniform management strategies. Empirical validation through future clinical research is warranted.

Patient summary: This research looks at tumor rupture during robotic kidney surgery, which can happen but is rare. The study involved a panel of experts who discussed finding a consensus on when it is more likely to occur and how to manage it effectively to reduce risks. It was also emphasized that while a rupture may not always lead to cancer spreading, the impact on a patient's health can vary and is yet to be determined.

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1. Introduction

With advancements in minimally invasive surgery, robot-assisted partial nephrectomy (RAPN) has become the preferred approach for managing renal tumors [1].

During RAPN, tumor rupture can occur: the occurrence is reported in 15% of cases on average. While this percentage may seem high, the limited number of studies reporting this complication, combined with the small absolute number of cases, makes it a rare and poorly studied phenomenon to date [2].

The risk of tumor rupture remains a concern due to its hypothetical potential to spread malignant cells beyond the renal parenchyma, leading to local recurrence or distant metastases [2].

Although some initiatives for standardized reporting of tumor rupture and/or "capsulotomy" have been proposed [3], these have not been adopted widely in the literature, likely due to factors such as limited consensus and a lack of clear clinical impact. The scarce literature on the topic suggests that tumor rupture, particularly in cystic tumors, does not increase the risk of progression [4,5].

Notwithstanding the importance of such an adverse event during oncological surgery, there is a lack of evidence on how to manage tumor rupture during RAPN. To address this gap, a Delphi consensus study was undertaken to define the event of tumor rupture during RAPN and suggest risk factors, management strategies, and related oncological implications.

2. Patients and methods

A modified Delphi method developed consensus statements on tumor rupture during RAPN following the ACcurate COnsensus Reporting Document (ACCORD) checklist for reporting consensus methods [6]. A five-phase process

based on the modified Delphi method was implemented to promote anonymity, control the influence of authoritative voices, and provide participant feedback.

2.1. Steering committee

A project steering committee was established, comprising an international and prominent panel of ten experts from the European Association of Urology (EAU) Robotic Urology Section, the EAU Renal Cell Cancer Guidelines panel, the Young Academic Urologists Kidney Cancer Working Party, and the Society of Urologic Robotic Surgeons.

2.2. Formulation of statements

A systematic review of resection techniques during RAPN was completed and published. This confirmed that reports of tumor rupture are anecdotal, with discussions about risk factors, management strategies, and implications being almost entirely unreported [7]. The expert panel convened for an online meeting, which served as the foundation for the decision-making process regarding the statements. During this meeting, the expert panel brainstormed about a tentative definition, together with a list of potential risk factors, management strategies, and oncological implications of tumor rupture during RAPN. The final list of statements was drafted (Table 1). The consensus rules were also determined, and an extended experts' panel composition was finalized. The panel members were selected to represent a broad range of expertise from leading societies based on their contributions to research in the field, their participation in kidney cancer guideline panels, and their involvement during EAU-endorsed live surgery meetings. This selection ensured diverse perspectives on the definition, risk factors, management strategies, and oncological implications of tumor rupture during RAPN.

2.3. Delphi—first round

A two-phase modified Delphi approach combined elements from the Delphi method and consensus development techniques [8]. Statements were submitted as an online survey from May to June 2024. The 33 panelists were asked to state their strength of agreement on a scale of 1 (strongly disagree) to 9 (strongly agree). Descriptive statistics were used to summarize the results of the Delphi round, which included calculating the percentage of participants who scored each statement as 1–3 (disagree), 4–6 (equivocal), and 7–9 (agree) [9]. Consensus was defined as follows: (1) $\geq$70% scoring a statement 7–9 and $\leq$20% scoring the statement 1–3 (consensus agree) or (2) $\geq$70% scoring a statement 1–3 and $\leq$20% scoring the statement 7–9 (consensus disagree). For each question, the Delphi process was stopped either when the agreement was reached or after the completion of the second round.

2.4. Delphi—second round

An online meeting with the extended panel was held in August 2024 to review the statements that reached consensus in the Delphi survey and to discuss those statements upon which there was no consensus. This was conducted asynchronously. Instead of a moderator presenting the results from the previous round, charts were used to display the responses from round 1: each panel member was shown a distribution of the group scores across the 1–9 scale for each statement and allowed to use this information to consider either retaining or changing the score assigned at round 1. The voting rules were the same as in the first round. All voting results were anonymous to minimize bias and influence.

3. Results

The steering committee formulated 58 statements into seven domains:

1. Definition of tumor rupture
2. Patient-related risk factors
3. Tumor-related risk factors
4. Surgical technique–related risk factors (encompassing both actions performed by the console surgeon and those by the bedside assistant)
5. Management of tumor rupture
6. Independent factors of tumor cell spreading
7. Prognostic factors after the occurrence of tumor rupture.

The statements were submitted to an international panel of 33 experts from ten countries across three continents in the first online Delphi survey. The consensus was reached for 18 (31%) statements, of which 11 were in agreement and seven were in disagreement. The other 40 (69%) statements were discussed during the consensus meeting. None required modifications to improve clarity before the second round. After the second Delphi survey, consensus was reached for 15 (37.5%) out of the 40 remaining statements for discussion, ten on agreement and five on disagreement, with answers from 30 out of 33 panelists. The consensus results for all statements are detailed below and summarized in Table 1. Fig. 1 summarizes a graphical representation of patient and tumor factors the contribution of which to tumor rupture was agreed upon by the panel.

4. Discussion

Although tumor rupture during RAPN is reported rarely, it could represent a significant intraoperative adverse event with potentially detrimental implications for patient oncological outcomes. Clear evidence-based statements regarding tumor rupture and optimal management strategies are currently lacking, reflecting the limited data available. Most information on this topic is derived from anecdotal reports rather than robust clinical studies, which constrains our ability to establish standardized recommendations.

While RAPN is nowadays preferred for its minimally invasive nature, precision, and reduced perioperative morbidity compared with open surgery, the risk of tumor rupture during the procedure warrants careful consideration, as the insufflation of carbon dioxide during minimally invasive surgery has historically been proposed as a potential promoter of intraperitoneal dissemination of cancer cells

Table 1 – Consensus results for all statements

Domains and statements		First round				Second round				Final consensus status
		Disagree (1–3)	Equivocal (4–6)	Agree (7–9)	Consensus status	Disagree (1–3)	Equivocal (4–6)	Agree (7–9)	Consensus status	
Definition of tumor rupture										
1	Tumor rupture refers to any event involving the exposure of cancer tissue within the capsule, with or without gross spreading within the surgical field	9%	2%	79%	Agree					Agree
Patient-related risk factors										
1	Specific patient's features could contribute to tumor rupture	18%	18%	64%	Not reached	–	7%	93%	Agree	Agree
2	Higher body mass index contributes	43%	27%	30%	Not reached	30%	20%	50%	Not reached	Equivocal
3	Visceral adiposity contributes	33%	15%	52%	Not reached	17%	3%	80%	Agree	Agree
4	Smoker status contributes	64%	27%	9%	Not reached	83%	10%	7%	Disagree	Disagree
5	Hypertension contributes	76%	12%	12%	Disagree					Disagree
6	Diabetes contributes	61%	21%	18%	Not reached	80%	13%	7%	Disagree	Disagree
7	Use of antiplatelets/anticoagulants contributes	73%	18%	9%	Disagree					Disagree
8	History of previous abdominal surgery contributes	52%	27%	21%	Not reached	60%	20%	20%	Not reached	Equivocal
9	History of previous upper tract endoscopic surgery contributes	55%	30%	15%	Not reached	70%	27%	3%	Disagree	Disagree
10	History of previous kidney surgery contributes	6%	18%	76%	Agree					Agree
11	Among previous kidney surgeries, nephron-sparing treatment is more impacting	6%	15%	79%	Agree					Agree
Tumor-related risk factors										
1	Increasing tumor size contributes	18%	27%	55%	Not reached	13%	13%	74%	Agree	Agree
2	Increasing tumor endophytic pattern contributes	6%	24%	70%	Agree					Agree
3	Increasing tumor complexity (ie, nearness to major vessels and/or collecting system) contributes	12%	27%	61%	Not reached	10%	17%	73%	Agree	Agree
4	Presence of cystic component contributes	–	9%	91%	Agree					Agree
5	Presence of necrosis contributes	15%	30%	55%	Not reached	4%	33%	63%	Not reached	Equivocal
6	Presence of tumor bulging/irregularity contributes	6%	12%	82%	Agree					Agree
7	Presence of peritumoral venous thrombosis contributes	18%	27%	55%	Not reached	16%	27%	57%	Not reached	Equivocal
8	Invasion of the urinary collecting system contributes	30%	27%	43%	Not reached	30%	30%	40%	Not reached	Equivocal
9	Infiltration of the sinus fat contributes	24%	36%	40%	Not reached	36%	36%	28%	Not reached	Equivocal
10	Presence of thick and/or sticky peritumoral fat contributes	9%	9%	82%	Agree					Agree
Surgical technique–related risk factors										
1	Tumor rupture is more likely during off-clamp approach—if compared with on-clamp one (included a proper selective clamping)	21%	24%	55%	Not reached	20%	13%	67%	Not reached	Equivocal
2	Tumor rupture is more likely if radial nephrotomy is performed—if compared with circumferential nephrotomy	36%	46%	18%	Not reached	26%	67%	7%	Not reached	Equivocal
3	Tumor rupture is more likely during enucleation—if compared with (enucleo) resection	24%	27%	49%	Not reached	10%	23%	67%	Not reached	Equivocal
4	Tumor rupture is more likely if Maryland bipolar forceps are used instead of fenestrated bipolar forceps	30%	33%	37%	Not reached	13%	37%	50%	Not reached	Equivocal
5	Tumor rupture is more likely if large needle driver is used as grasper on the 4th arm instead of Prograsp/Cadiere forceps	43%	30%	27%	Not reached	40%	30%	30%	Not reached	Equivocal
6	Specific maneuvers performed by the bedside assistant could contribute to tumor rupture	12%	27%	61%	Not reached	3%	20%	77%	Agree	Agree
7	Among such maneuvers, traction of the tumor contributes	3%	9%	88%	Agree					Agree
8	Among such maneuvers, traction of the adjacent renal parenchyma contributes	24%	21%	55%	Not reached	3%	14%	83%	Agree	Agree
9	Among such maneuvers, performance in suction/irrigation contributes	21%	33%	46%	Not reached	17%	30%	53%	Not reached	Equivocal
10	Among such maneuvers, errors in delivering needles contributes	33%	46%	21%	Not reached	50%	37%	13%	Not reached	Equivocal
11	Among such maneuvers, errors in robotic instrument exchange contributes	40%	33%	27%	Not reached	27%	53%	20%	Not reached	Equivocal
Management of tumor rupture										
1	For the prompt removal of the cancer tissue spilled out, suction is advisable over grasping and retrieval	3%	30%	67%	Not reached	–	7%	93%	Agree	Agree
2	In case of tumor rupture, irrigation of the surgical field is recommended	43%	27%	30%	Not reached	50%	23%	27%	Not reached	Equivocal

Table 1 (*continued*)

Domains and statements		First round				Second round				Final consensus status
		Disagree (1–3)	Equivocal (4–6)	Agree (7–9)	Consensus status	Disagree (1–3)	Equivocal (4–6)	Agree (7–9)	Consensus status	
3	In case of tumor rupture, introduction of a gauze to aid in cleaning the surgical field is recommended	43%	33%	24%	Not reached	60%	23%	17%	Not reached	Equivocal
4	In case of tumor rupture, immediate entrapment of the tumor specimen into an endobag is recommended	3%	6%	91%	Agree					Agree
5	In case of tumor rupture, additional widened resection of the renal parenchyma surrounding the site of rupture is recommended	36%	28%	36%	Not reached	57%	10%	33%	Not reached	Equivocal
6	In case of tumor rupture, performance of frozen section of the mass is recommended	76%	21%	3%	Disagree					Disagree
7	In case of tumor rupture, performance of frozen section of the resection bed is recommended	79%	18%	3	Disagree					Disagree
8	After tumor rupture has occurred, conversion to radical nephrectomy is recommended in any case	91%	9%	–	Disagree					Disagree
9	After tumor rupture has occurred, conversion to radical nephrectomy is recommended only if there is gross evidence of residual cancer in the kidney	9%	27%	64%	Not reached	13%	3%	84%	Agree	Agree
10	After tumor rupture has occurred, conversion to radical nephrectomy is recommended only if there is evidence of diffuse spreading of cancer cells	40%	36%	24%	Not reached	67%	17%	16%	Not reached	Equivocal
11	After tumor rupture has occurred, conversion to open approach is recommended in any case	85%	15%	–	Disagree					Disagree
12	After tumor rupture has occurred, conversion to open approach is recommended only if there is gross evidence of residual cancer in the kidney	79%	15%	6%	Disagree					Disagree
13	After tumor rupture has occurred, conversion to open approach is recommended only if there is evidence of diffuse spreading of cancer cells	64%	21%	15%	Not reached	90%	7%	3%	Disagree	Disagree
Independent factors of cancer cells spreading after tumor rupture										
1	After tumor rupture, spreading of tumor cells is likely influenced by the laparoscopic route (transperitoneal vs retroperitoneal)	39%	22%	39%	Not reached	60%	3%	37%	Not reached	Equivocal
2	After tumor rupture, spreading of tumor cells is likely influenced by the insufflation system (standard vs advanced)	36	42	22	Not reached	63%	10%	27%	Not reached	Equivocal
3	After tumor rupture, spreading of tumor cells is likely influenced by CO2 pressure, ie, lower pressure equals lower spreading	46%	39%	15%	Not reached	53%	37%	10%	Not reached	Equivocal
4	After tumor rupture, spreading of tumor cells is likely influenced by how quickly the tumor is placed into an endobag	21%	37%	42%	Not reached	10%	20%	70%	Agree	Agree
5	Spreading of tumor cells will likely be reduced by deflating the pneumoperitoneum before laparoscopic ports and specimen extraction	52%	30%	18%	Not reached	67%	23%	10%	Not reached	Equivocal
Prognostic factors after tumor rupture										
1	Biological and/or clinical relevance of tumor rupture is unpredictable, as largely dependent on tumor features	6%	18%	76%	Agree					Agree
2	Biological and/or clinical relevance of tumor rupture is likely to be higher in the case of gross rupture than in case of focal rupture	12%	9%	79%	Agree					Agree
3	Biological and/or clinical relevance of tumor rupture is likely to be higher in the case of rupture of solid masses than in case of masses with cystic component	15%	46%	39%	Not reached	23%	17%	60%	Not reached	Equivocal
4	In the event of exposure of cancer tissue with spreading of any degree within the surgical field, the biological and/or clinical relevance of tumor rupture is influenced by whether the spilled out tumor is (macroscopically) 100% removed	15%	30%	55%	Not reached	7%	13%	80%	Agree	Agree
5	Tumor rupture is likely predictive of tumor local recurrence (at the site of resection)	21%	49%	30%	Not reached	20%	37%	43%	Not reached	Equivocal
6	Tumor rupture is likely predictive of tumor recurrence at distant locations, including peritoneal carcinosis	24%	40%	36%	Not reached	24%	33%	43%	Not reached	Equivocal
7	Tumor rupture is likely predictive of distant metastases	55%	30%	15%	Not reached	87%	10%	3%	Disagree	Disagree

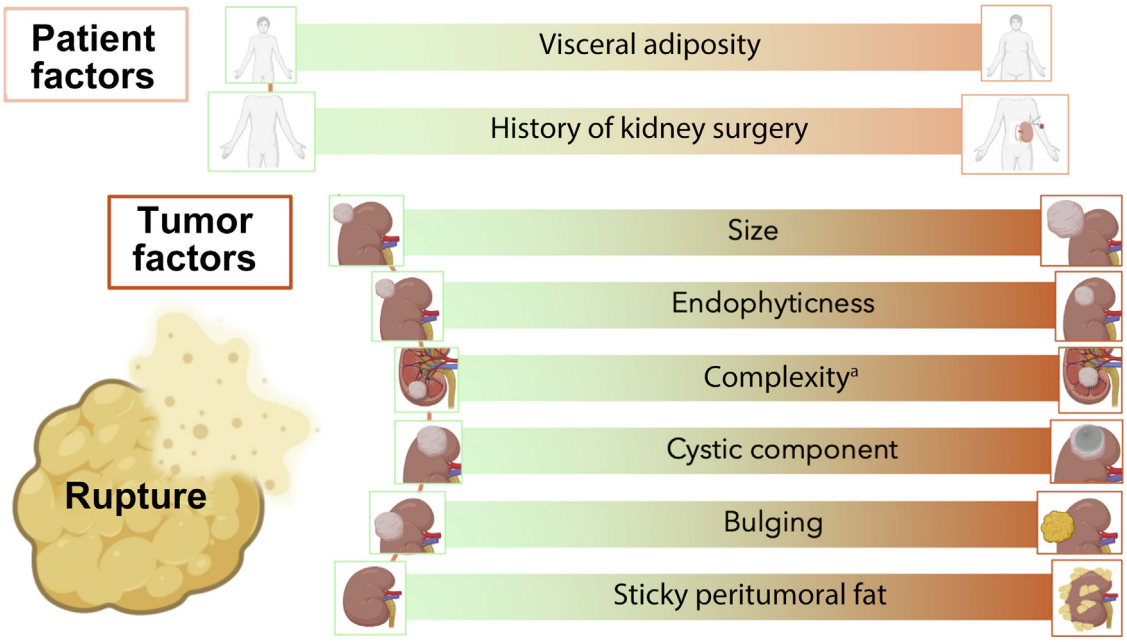

Fig. 1 – Graphical summary of patient and tumor factors the contribution of which to tumor rupture was agreed upon by the panel. The green color signifies a lower risk of tumor rupture than the orange color, based on the opinion of the expert panel (created in BioRender.com). [a]That is, nearness to major vessels and/or collecting system.

[10]. On the contrary, tumor (histology, grade, sarcomatoid features, etc.) and patient (comorbidities, age, frailty, immune system competence, etc.) characteristics are likely to be the most significant factors that may influence the natural history, regardless of a possible rupture during surgery.

In support of the above, a recent series reported on patients treated with minimally invasive partial or radical nephrectomy who developed atypical tumor recurrences involving port sites, perinephric implants, and carcinomatosis. Many of these operations were performed by leading surgeons, and an examination of the operative reports revealed no technical aberrations or overt spills, raising the possibility that mechanisms of atypical recurrence, in addition to overt spillage or tumor rupture, may be at play [11].

Most urologists believe that tumor rupture during RAPN can occur due to multiple factors, including specific tumor characteristics, improper handling of the tumor, excessive manipulation during excision, and technical challenges inherent to the robotic approach. In cases where tumor rupture occurs, the intraoperative management strategy becomes crucial. Additionally, whenever tumor rupture occurs, it carries the risk of tumor spillage, which could potentially lead to peritoneal seeding and increase the risk of local recurrence or distant metastasis. While the consequences of tumor rupture can be well documented for other cancers in terms of worsened prognosis, the data specifically addressing renal cell carcinoma rupture during RAPN has remained limited. Oncological follow-up is usually more rigorous due to the potentially higher likelihood of disease recurrence.

The RUPTURE project was conceived in this uncertain setting and lacking literature. We felt that applying the Delphi method to a panel of selected experts in the field was the best way to start. Several domains were considered, namely, the definition of tumor rupture, patient-related risk factors, tumor-related risk factors, surgical technique–related risk factors (encompassing the actions performed by both the console surgeon and the bedside assistant), how to manage tumor rupture, independent factors of tumor cell spreading, and prognostic factors after tumor rupture occurs. The panel reached a consensus on the definition of tumor rupture, which refers to any event involving the exposure of cancer tissue within the capsule of the excised mass. An accent was placed on the degree of spreading of cancerous tissue in the surgical field, gross versus minimal: the panel recognized this evaluation as very arbitrary but anticipated that it could translate into different prognostic implications.

Several statements regarded specific patient factors that could contribute to the likelihood of tumor rupture. A consensus was reached that high visceral adiposity and a previous history of kidney surgery—particularly nephron-sparing surgery—increase the likelihood of tumor rupture. These factors may surrogate or predict a challenging kidney and tumor dissection from the perirenal fat. Accordingly, the panel agreed that the presence of sticky fat during the preparation of the kidney could also increase the likelihood of rupture. On the contrary, consensus was reached that there is no relationship between tumor rupture and smoker status, hypertension, diabetes, and use of antiplatelets or anticoagulants. Although we know that these patient variables also impact the "quality" of the perirenal fat to be dissected [12], the panel did not consider these to be significantly associated with an increased risk of tumor rupture. Finally, the panel also agreed that previous upper tract endoscopic surgeries do not increase the likelihood of

tumor rupture, reasonably because, in the worst-case scenario, there is indeed some extravasation of saline solution during irrigation, that is, ureterorenoscopy; yet, this is not enough to compromise the dissection of the kidney to the point of impacting on the likelihood of tumor rupture.

Concerning tumor characteristics that contribute to tumor rupture, the panel reached a consensus on the role of increasing tumor size and complexity (ie, nearness to major vessels and/or collecting system), endophytic growth pattern, presence of a cystic component, and bulging and/or irregularities on the outer surface of the tumor to be excised. It is logical to think that a larger tumor will be more difficult to handle. It will also be heavier, potentially rupturing simply due to its weight, putting strain on the tip of the instrument used to lift it. As for the complexity of the lesion, a more endophytic pattern may require stronger tractions during dissection. It is also possible that an endophytic lesion may need to be removed with a smaller amount of healthy perilesional parenchyma, thus reducing the "protection" of the tumor from traction forces. The relationship between the tumor growth pattern/complexity and the likelihood of tumor rupture has already been reported by the few available literature on the topic [4,13,14].

The cystic tumor pattern is definitely a risk factor for rupture, as evidenced by the fact that most of the few papers published investigating tumor rupture focus on cystic tumors [2,5,14]. By contrast, although extensive intratumoral necrosis can make the tumor as fragile as a cyst, the panel did not reach a consensus on the role of necrosis in contributing to tumor rupture. Finally, tumor bulging and/or irregularities can represent a challenge during anatomical resection. In the case of tumor bulging, one should distinguish between rupture and the critical error of dissection plane misidentification, where dissection continues into the tumor. In either case, both result in discontinuity of the capsule, potentially leaving tumor tissue on the healthy side of the kidney. Although this aspect was not specifically addressed in the Delphi statements, intraoperative ultrasonography may help prevent tumor rupture in irregular neoplasms. Finally, one should note that the unresectability of a very endophytic lesion, with eventual bulging and/or irregularities, and an incorrect indication for conservative surgery could independently contribute to tumor effraction.

As for surgical technique issues potentially contributing to tumor rupture, no consensus was reached on the role of specific surgical maneuvers by the console surgeon or the choice of robotic instruments in contributing to tumor rupture.

In general, most tumor ruptures would result from surgical technical errors, with risk being inversely proportional to the surgeon's experience and case volume. Anecdotal reports about tumor rupture indeed suggested that low surgeon experience may independently contribute to tumor rupture [13,14].

Such a premise seemed self-evident during the pre-Delphi brainstorming. The panel focused on investigating several technical aspects related to the console surgeon's choices during RAPN, which included deciding on an off-clamp versus an on-clamp approach for tumor resection, choosing to perform a radial nephrotomy versus a circumferential one to approach a fully endophytic lesion, opting for tumor enucleation versus enucleoresection, using the Maryland bipolar forceps rather than the fenestrated ones as the nondominant hand instrument (hypothesizing that the Maryland bipolar forceps had tips that might increase the likelihood of rupture), and employing the needle holder as the fourth-arm instrument instead of Cadiere or Prograsp until renorrhaphy is initiated (the needle-holder tips, not conceived for grasping, could injure the tumor).

The lack of consensus likely reflects the current variability in practice and limited evidence on specific technique-related factors influencing rupture risk during RAPN. The panel's diverse perspectives underscore the need for further studies to assess these technical elements' impact objectively. Such a lack of agreement may also be attributable to a kind of "surgeon bias," particularly within such a panel of esteemed experts.

On the contrary, the panel agreed on the significant impact of the bedside assistant's actions in causing tumor rupture, particularly the traction applied to either the tumor or the adjacent renal parenchyma during resection. This could reflect a common yet flawed mindset: "it's never us; it's always the other." Actually, only one retrospective experience highlighted the relationship between tumor rupture and the assistant's experience [4]. The results from the present effort might be an opportunity to reinforce the importance of being assisted by skilled bedside surgeons during RAPN, especially as tumor complexity increases. It is essential to acknowledge that while the selection of an expert surgeon to assist in the procedure is the responsibility of the primary surgeon at the console, the correct mindset should be: "It is always our responsibility; mistakes can happen, and this is unavoidable, even in the most experienced hands."

Concerning the management of an accidental tumor rupture, the panel suggested that suction may be preferable to grasping and retrieval for removing spilled cancerous tissue. In cases of tumor spillage, suction is theoretically preferable to grasping for several reasons: grasping spilled tissue, and repeatedly retrieving the laparoscopic grasper through the trocar may increase the risk of port site seeding due to tissue contact. Conversely, the use of a laparoscopic suction-irrigation cannula removes cancerous tissue efficiently while minimizing the likelihood of tissue remnants in the trocar. While this recommendation is hypothesis driven and lacks direct scientific evidence, it reflects a cautious strategy to minimize the potential risk of metachronous cancer cell seeding at port sites following trocar removal. Although further research is needed to substantiate this approach, it provides a practical consideration for surgical practice in the absence of stronger evidence. We believe that this is an important message with the potential to uniform the approach. This could be tested in future prospective studies to evaluate whether it actually reduces the risk of metachronous seeding of cancer cells at port sites after trocar removal. An agreement was reached on the necessity of promptly entrapping the tumor in an endobag after a rupture occurs to logically reduce the time the exposed cancerous tissue is in contact with surrounding tis-

sues, particularly the pneumoperitoneum. By contrast, the panel reached consensus in disagreement on several points, namely, the performance of a frozen section of either the mass or the resection bed, the need to convert to radical nephrectomy in all cases, and the need to switch to an open approach in any case and also in cases where there is gross evidence of residual cancer in the kidney or diffuse spreading of cancer cells. The panel agreed on the opportunity to convert the surgery to radical nephrectomy only if, after rupture, there is still gross evidence of residual cancer in the kidney. These are other important messages. Besides the expected inadvisability of frozen sections, whether from the tumor itself or the resection bed, it is acknowledged by the present effort that conversion to open surgery or radical nephrectomy is generally not recommended. This challenges a long-standing dogma often mentioned at international conferences when accidental tumor rupture occurs during live surgeries. As a rule, surgeons experiencing tumor rupture should proceed with tumor resection and abstain from conversion to radical nephrectomy or open partial nephrectomy. On the contrary, the panel agreed that conversion to radical nephrectomy while maintaining a laparoscopic approach may be considered when macroscopic residual tumor tissue remains on the kidney and is deemed unresectable.

If the decision is made to proceed with RAPN despite tumor rupture and avoid conversion, it is crucial to acknowledge the associated risk of prolonged ischemia time [15].

The panel also discussed potential independent factors influencing the spread of cancer cells after tumor rupture and agreed that this is affected by how quickly the tumor is placed in an endobag. This aligns with the recommended prompt bagging of the tumor among the suggested management actions. Instead, the panel could not agree on the contribution of the laparoscopic route (transperitoneal vs retroperitoneal), intra-abdominal pressure, use of advanced insufflation systems, or the potential benefit of lowering CO_2 insufflation pressure before robot undocking and ports' and specimen's removal in relation to the spread of cancer cells after an eventual tumor rupture.

Importantly, the panel agreed that the biological and clinical significance of tumor rupture is unpredictable, largely depending on the specific characteristics of the ruptured mass. In the event of exposure of cancer tissue with spreading of any degree within the surgical field, the panel agreed that the biological and/or clinical relevance of such rupture will be influenced by whether the spilled out tumor is macroscopically 100% removed. Interestingly, consensus was reached that the oncological impact of tumor rupture may differ between gross and focal tumor rupture cases. However, we still lack a standardized definition of what constitutes focal and gross tumor rupture in this context. Overall, the scarce literature would suggest that most tumor ruptures, regardless of the cystic or solid nature of the mass, have negligible prognostic significance. Only one study reported tumor rupture as an independent factor of higher recurrence rate and worsened survival outcomes [2]. That said, the panel did not reach a consensus regarding the association between tumor rupture and an increased likelihood of recurrence at the tumor site or peritoneal carcinomatosis, which have otherwise been considered concerning metachronous findings following tumor rupture. Finally, consensus was reached on the lack of association between tumor rupture and the occurrence of distant metastases. Although consensus was not reached on these statements, it is common practice that postoperative surveillance should be more frequent in these unfortunate situations.

While this Delphi consensus offers valuable initial insights into tumor rupture during RAPN, several limitations should be acknowledged. The study's reliance on expert opinion reflects the scarcity of robust empirical evidence on this topic, particularly in surgical techniques and management strategies. As a result, some recommendations may reflect current expert practices rather than universally applicable conclusions. Additionally, while beneficial, the high level of expertise among panelists introduces a potential bias where technical considerations may not generalize to less experienced surgical settings. Furthermore, the consensus reached relies heavily on subjective assessments, which limits reproducibility and may not comprehensively represent all aspects of this complex issue. Addressing these limitations in future research through empirical studies will be essential to validate and refine these preliminary recommendations.

This consensus would serve as a foundation to encourage more structured research efforts that can produce higher levels of evidence. This panel's recommendations offer a starting point by raising awareness of the risks associated with tumor rupture during RAPN and promoting the need for comprehensive studies.

Given the inherent challenges and hesitations in publishing data on complications, particularly such as tumor rupture, it is likely that this condition is under-reported in the literature: the scarcity of literature discussing tumor rupture contrasts with the average 15% incidence reported in the studies that address it. We strongly encourage reporting "uncomfortable" data to provide a more accurate understanding of the incidence and management of such complications.

As part of the second step of the RUPTURE project, we are designing a prospective multicentric data collection system associated with a video library. This will be crucial for gaining a comprehensive understanding of standardized definitions, risk factors, and management protocols for tumor rupture across different skill levels.

5. Conclusions

This consensus forms a basis for future research on tumor rupture in RAPN, emphasizing standardized definitions and uniform management strategies. Empirical validation through future clinical research is warranted.

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Study concept and design: Bertolo, Antonelli, Mottrie.
Acquisition of data: Bertolo.
Analysis and interpretation of data: Bertolo, Antonelli, Mottrie.
Drafting of the manuscript: Bertolo.
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