New anatomical considerations in planning renal surgery

V. Ficarra, F. Zattoni, M. Rossanese, G. Giannarini, Udine (IT)

The first-generation of renal tumor complexity scoring systems are the R.E.N.A.L. nephrometry score, the PADUA classification, and the Centrality index (CI) [1-3]. Both PADUA and R.E.N.A.L. nephrometry systems combine tumor's characteristics (like clinical tumor size) with tumor's geographic location in the kidney (such as tumor deepening into the parenchyma and longitudinal location) and tumor's involvement of kidney anatomical structures (like renal sinus and/or urinary collecting system). The main differences between PADUA and R.E.N.A.L. are the grading points given to collecting system and tumor rim location. In detail, the PADUA score is a 14 points scale, which assess the collecting system and the renal sinus separately. In attrition, those tumors in the medial rim are considered at higher risk of complications in comparison to those in a lateral position. On the contrary, the R.E.N.A.L score is a 12 points scale which set the tumor involvement of renal sinus with the same prognostic value of the collecting system and elude difference for tumor's rim location. Both PADUA and R.E.N.A.L score combine each parameters in a final score that allows surgeon to classify tumors suitable for PN in low-, intermediate- and high-risk complexity categories [1, 2].

The CI differs significantly from PADUA and R.E.N.A.L score because it asses a continuous index based on tumor size and distance from the periphery of the tumor to the center of the kidney. The higher is the CI value the easier is expected to be the surgical resection [3].
Data from Literature showed that RENAL and PADUA classification are more popular and widely used in comparison with the Centrality index [4]. Several studies tested the ability of RENAL and PADUA score to predict the most important perioperative outcomes in patients who underwent PN for parenchymal renal tumors for both open and robotic surgery. Both systems predicted overall complications, ischemia time and estimated blood loss. Conversely, few studies validated the CI ability to predict ischemia time and post-operative complications [4]. Interestingly, the first-generation nephrometry systems turned out to be independent predictors for functional outcomes after PN in terms of absolute change of eGFR or percentage change of eGFR [4]. It follows that, the use of a nephrometry system should be strongly recommended in the daily clinical practice [5].

With the aim to simplify previous nephrometry tools and to improve their ability to predict perioperative and functional outcomes, a second-generation of systems have been recently proposed. Of these, the most popular are: the Diameter-axial-polar (DAP) nephrometry system [6], the Zonal Nephro scoring system [7] and the Arterial Based Complexity (ABC) scoring system [8]. The Diameter-axial-polar (DAP) nephrometry system seems to integrate the optimized attributes of the RENAL and C-index systems measuring the diameter score, the axial distance score and the polar distance score [6]. The Zonal NePhRo scoring system looks more complex that previous evaluating the nearness of the tumor, the physical zone, the radius and the organization of the tumor [7]. More originally, Spaliviero et al [8] proposed a new system based on the relationship between the tumor and the interlobular and arcuate arteries (score 1); interlobar arteries (score 2); segmental arteries (score 3S) and renal hilum (score 3H).
The second-generation nephrometry systems resulted able to predict perioperative outcomes in the original studies. However, most of these interesting novel systems were not appropriately compared with the first-generation tools and/or externally validated. Thus, further studies are needed before their extensive use in clinical practice. Table 1 summarizes the characteristics of the available first and second-generation nephrometry scores.

Other authors highlighted the potential role of novel parameters to predict perioperative and functional PN outcomes. In this context, the renal tumor contact surface area (CSA) and the characteristics of perirenal fat tissue have been the more investigated parameters [9, 10]. In 2014 Leslie et al [9] demonstrated that CSA > 20 cm2 correlated with adverse tumor characteristics (greater tumor size, volume, and complexity) and perioperative outcomes (more parenchymal volume loss, blood loss, and complications) compared with CSA <20 cm2. Moreover, on multivariable logistic regression, CSA independently predicted operative time, complications, hospital stay, and renal functional outcomes [9].

Unquestionably, Adherent Perinephric Fat (APF) is a known risk factor for a challenging PN. In 2014, Davidiuk et al [10] proposed the Mayo Adhesive Probability Score, an image-based scoring system to predict the APF in patients suitable for PN. The score is essential based on posterior perinephric fat thickness and grading of perinephric stranding [10]. This parameter seems to be associated with EBL and operative time.

Renal arterial vasculature can represent another interesting anatomical factor for PN preoperative planning. In a unpublished anatomical study of our team, we recently observed that human kidneys have an arterial vasculature frequently different from the well known Graves description [11]. Moreover, in a significant percentage of cases, a single renal segment receives two or more branches coming from a segmental artery destined to another segment. We observed collateral arterial blood-supply between the different segments in 80% of analyzed casts. This finding was more represented at level of middle and inferior poles. The presence of these collateral arterial vessels could explain the selective clamping failure during PN.

Looking at the near future, an interesting perspective is represented by the application of 3D printing technology in preoperative surgical planning [12]. Nephrometry systems could be used to select high complex cases in which printed 3D models could help the surgeon to plan a more appropriate surgical strategy to remove entirely the tumor minimizing the risk of complications. Alternatively, the use of 3D printing technology could generate a new modality to evaluate preoperatively patients suitable for PN minimizing the role of current 2D nephrometry systems. The application of 3D printing technology in the field of nephron-sparing surgery is still in her infancy however, great potentiality is expected from this new technology.

In conclusion, Nephrometry systems are effective tools to predict perioperative and functional outcomes in patients suitable to PN. Unfortunately, few data are available regarding their prognostic ability for local tumor recurrence and progression.
Tumor Contact Surface Area and the Renal Arterial Vascolature are the most interesting novel anatomical parameters to be considered in the PN strategy. Finally, 3D models represent the most promising and fascinating tool to improve intraoperative strategy and perioperative outcomes in the near future.

References

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