New staging and scoring systems of renal cell carcinomas: what the radiologist needs to report.

Poster No.: C-0701
Congress: ECR 2015
Type: Educational Exhibit
Authors: P. Leitão¹, A. Carvalho², F. Rego Costa², J. Goncalves²; ¹Lisbon/PT, ²Porto/PT
Keywords: MR, CT, Urinary Tract / Bladder, Oncology, Staging, Multidisciplinary cancer care
DOI: 10.1594/ecr2015/C-0701

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys’ fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

1. To categorize the renal cell carcinomas (RCCs) and their imaging characteristics;
2. To review the new staging and scoring methods available;
3. To illustrate various renal tumors using the new scoring systems by means of pictorial examples.
Background

The commonest kidney malignancy is renal cell carcinoma (90% of all renal tumors) \[^1\], which consist in different subtypes with specific histopathological and genetic characteristics. The clear cell carcinoma is the most common histologic subtype, accounting for 70%-80% of all RCCs \[^1\].

With the widespread use of ultrasound and CT, most RCCs are now diagnosed incidentally during imaging performed for other reasons, leading to an earlier diagnosis \[^2\]. Consequently, the tumors have smaller sizes and are at lower stages at diagnosis. These smaller lesions raise problems not only in terms of imaging characterization but also about treatment options. Nowadays the decision is no more between a wait-and-see approach or total nephrectomy, but instead between a myriad of therapeutic options, from nephron-sparing surgery to tumor ablation techniques \[^3\].

With that in mind it was necessary to go beyond the TNM staging system and creating new scoring systems that helps planning the best treatment approach. Among them are the R.E.N.A.L. nephrometry schemes, the C-Index scoring, the P.A.D.U.A. classification and the A.B.L.A.T.E. algorithm.
Findings and procedure details

The renal neoplasms can be divided into different subtypes according to their cell origin (table 1).

Renal cell carcinoma is the most common renal tumor and is divided in clear cell carcinoma (70-80%), papillary (10-15%), chromophobe (5%), collecting duct carcinoma and renal medullary carcinoma (2-5%) [4]. Table 2 summarizes the main imaging characteristics of the renal cell carcinomas and other lesions that should be excluded when a mass is found, including benign lesions that shouldn’t be treated. Although there are multiple imaging characteristics about renal masses the radiologist should know, none of them is specific and the definite diagnosis can only be made by biopsy [5].

When a renal mass is discovered and other, non-neoplastic, causes are excluded, tumor characterization is the next step. More important than trying to categorize the tumor subtype is to characterize the mass. The scoring systems allow an objective, standardized and reproducible anatomic classification of renal tumors, helping in prediction the probability of complications of nephron-sparing surgeries. Studies confirmed that the three scoring systems demonstrate reliability among observers and represent methods of quantitatively describing renal tumors [8].

R.E.N.A.L. nephrometry:

The R.E.N.A.L. system was the first renal tumor complexity scoring system. It correlates with the tumor aggressiveness, complexity and rate of surgical complications [9]. The acronym relates to (R)adius (the maximal diameter (cm) of the tumor in any single plane), (E)ndophytic/exophytic properties (evaluates if the tumor abuts or not the renal capsule and in what percentage), (N)earness (distance of the medial limits of the tumor from the nearest portion of the renal sinus or collecting system), (A)nterior/posterior (evaluated by drawing a line in the axial plane paralleling the renal hilum and bisecting the renal parenchyma) and (L)ocation (masses are divided into polar or interpolar by drawing two lines in the axial or coronal planes that cross the medial lip of parenchyma interrupted by renal sinus fat) [10]. The parameters of this index are exposed in Table 3, with the correspondent scoring and followed by pictorical explanation (Fig. 1 to 7).

This system was proposed to classify the renal tumors suitable for conservative treatment based on their anatomical aspects and dimensions and to predict the risk of complications in the peri-operative period. The size of the tumor, location, face and exophytic/endophytic criteria are similar to those of R.E.N.A.L. system. The main differences are the involvement of the renal sinus and collecting system and the location of the mass relatively to the lateral or medial renal rims\cite{11}. The parameters of this index are exposed in Table 4, with the correspondent scoring, followed by pictorical explanation. (Fig. 8 to 13).

C-Index scoring:

The centrality index (C-Index) is a completely different system compared to the R.E.N.A.L. and P.A.D.U.A. because it involves a relatively complex mathematical concept. The objective of this system is to quantify the proximity of the tumor to the renal central sinus, since this parameter is of extreme importance for the surgical planning.

In order to calculate C-index a few steps have to be followed:

1. localize the first and last image sections in which the kidney appears: image numbers of these sections are averaged to calculate the middle image;
2. in the middle image, calculate a central reference point, which is the point in the center of an imaginary ellipse drawn around the periphery of the kidney;
3. identify the hilar reference point: with the cursor stabilized on the central axial reference point scroll until finding the hilum;
4. identify the image section with the largest tumor diameter;
5. calculate distance y (cm): number of sections between the middle image and the image with the largest tumor diameter divided by image slice thickness;
6. calculate distance x (cm): distance between the hilar axial reference point and the center of tumor;
7. measure the tumoral diameter (draw a line paralleling the "x" line);
8. calculate the tumoral radius (r) by halving its diameter;
9. calculate "c" distance based on Pythagorean Theorem: \(c/r = \sqrt{x^2 + y^2}\)
10. calculate C-index: c/r.

A centrality index of 0 indicates that the tumor is concentric with the center of the kidney; a c-index of 1 means the periphery touches the kidney center and as the centrality index increases the tumor periphery becomes more distant from the kidney center. Figures 14 to 18 shows the application of centrality index in a renal mass.

A.B.L.A.T.E. algorithm:
The A.B.L.A.T.E. algorithm, unlike the previous scoring systems, was developed in order to create a systematic method of planning ablation therapies. Ablation therapies such as cryoablation and radiofrequency ablation (RFA) are being used more often as they have proved to be effective in selected patients, namely those with T1a (# 4 cm) tumors and high surgical risk. Instead of calculating the risk of treatment complications, it calls the attention to the critical characteristics of the renal masses that can difficult the ablation therapy and suggest treatment approaches to overcome them. The parameters included in this system and their treatment suggestions are summarized in Table 5.
**Table 1:** Adapted from WHO Classification (2004) [4]. "Others" group includes: Collecting duct carcinoma (CDC), Renal medullary carcinoma (RMC), Xp11.2 translocation renal cell carcinoma, Neuroblastoma associated RCC, Mucinous tubular and spindle cell RCC and unclassificated RCCs.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
<table>
<thead>
<tr>
<th>Renal cell carcinoma</th>
<th>Growth pattern</th>
<th>Vascularity and contrast enhancement</th>
<th>Intralesional components</th>
<th>Multicentricity</th>
<th>Ultrasound and CT characteristics</th>
<th>MRI characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear cell carcinoma</td>
<td>Ball-type (expansive lesion)</td>
<td>High</td>
<td>- solid, heterogeneous; cystic change in 15% of cases; calcification in 10%-15% of cases</td>
<td>Rare</td>
<td>Enhancement on CT exceeds 84 HU in the corticomedullary phase and 44 HU in the excretory phase</td>
<td>Hypo-to isointense on T1-weighted MR images and iso- to hyperintense on T2-weighted MR images</td>
</tr>
<tr>
<td>Papillary renal cell carcinoma</td>
<td>Ball-type</td>
<td>Low</td>
<td>- Homogeneous; - Calcifications may be present (30%)</td>
<td>Common</td>
<td>Likelihood of papillary RCC is ~ 50% when tumor-to-aorta or tumor-to-kidney enhancement ratio is &lt; 0.25</td>
<td>Low signal intensity on T2-weighted MR images</td>
</tr>
<tr>
<td>Chromophobe</td>
<td>Ball-type</td>
<td>High</td>
<td>Homogeneous even if large</td>
<td>Not common</td>
<td>- Hyperecogenicity on ultrasound (mimics AML); - Spoke-wheel pattern may be present (mimics oncocytoma)</td>
<td>Hypointense on T2-Weighted images</td>
</tr>
<tr>
<td>Collecting duct carcinoma</td>
<td>Bean-type (infiltrative lesion with preservation of reniform shape)</td>
<td>Not too high</td>
<td>- Heterogeneous; - Calcifications may be present</td>
<td>Not common</td>
<td>Can be hyper, iso- or hypoechoic on ultrasound</td>
<td>Low signal intensity on T2-Weighted images</td>
</tr>
<tr>
<td>Renal medullary carcinoma</td>
<td>Bean-type</td>
<td>Not too high</td>
<td>Heterogeneous</td>
<td>Not common</td>
<td>Associated with caliectasias</td>
<td>Hypointense on T2-weighted images</td>
</tr>
</tbody>
</table>

**Table 2:** Subtypes of RCC and their differential diagnosis: imaging characteristics and behavior [1,6,7]. Continue...

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Table 3: Continued: Differential diagnosis of renal cell carcinomas: imaging characteristics and behavior [1,6,7].

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.

<table>
<thead>
<tr>
<th>Other renal masses</th>
<th>Growth pattern</th>
<th>Vascularity and contrast enhancement</th>
<th>Intrallesional components</th>
<th>Multicentricity</th>
<th>Ultrasound and CT characteristics</th>
<th>MRI characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition cell carcinoma</td>
<td>Bean-type</td>
<td>Low</td>
<td>Homogeneous (no necrosis or cystic changes)</td>
<td>Common</td>
<td>- Filling defect in the renal pelvis - Tumor centered in the collecting system</td>
<td>Not commonly used (poor spatial resolution)</td>
</tr>
<tr>
<td>Oncocytoma</td>
<td>Ball-type</td>
<td>High</td>
<td>Homogeneous (no necrosis or hemorrhage)</td>
<td>Not common</td>
<td>Spoke-wheel pattern</td>
<td>Difficult to distinguish from chromophobe</td>
</tr>
<tr>
<td>Angiomyolipoma (AML)</td>
<td>Ball-type</td>
<td>Enhancement is variable, depending on the amount of vascular and muscle components</td>
<td>Macroscopic fat is pathognomonic</td>
<td>Common in patients with Tuberous Sclerosis</td>
<td>Hyperecogenicity on ultrasound</td>
<td>- High signal intensity on T2 - India ink artifact on opposed-phaseT1 - Isointense relative to fat with all MR imaging sequences - Higher intensity than that of the parenchyma on T1 weighted images</td>
</tr>
<tr>
<td>Metastasis</td>
<td>Ball-type or bean-type</td>
<td>Variable</td>
<td>Heterogeneous</td>
<td>Common</td>
<td>Difficult to distinguish from RCC – needs biopsy</td>
<td>Variable</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>Ball-type</td>
<td>Low</td>
<td>Homogeneous even if large</td>
<td>Common</td>
<td>Hypoechoic mass</td>
<td>- Hypointense on T1 - Slightly hypointense or iso-intense relative to normal renal cortex on T2</td>
</tr>
</tbody>
</table>

**R – Radius**
- $\leq 4 \text{ cm}$: 1 point
- $4 - 7 \text{ cm}$: 2 points
- $\geq 7 \text{ cm}$: 3 points

**E – Exophytic/Endophytic**
- $> 50\%$ exophytic: 1 point
- $\leq 50\%$ exophytic: 2 points
- Totally endophytic: 3 points
- $> 7 \text{ mm}$: 1 point

**N – Nearness**
- $> 4 \text{ mm but less } \leq 7 \text{ mm}$: 2 points
- $\leq 4 \text{ mm}$: 3 points

**A – Anterior**
- Anterior (a)
- Posterior (p)
- Unknown (x)
- The tumor reaches the renal vein or artery - hilum (h)
- Above the superior polar line or below the inferior polar line: 1 point
- Crosses the polar line: 2 points

**L – Location**
- $> 50\%$ crosses the polar line: 3 points
- Crosses the axial midline: 3 points
- The entire tumor is located in the interpolar region: 3 points
**Table 4:** R.E.N.A.L. Index: 4-6 points: low complexity and low rate of complications; 7-9 points: moderate complexity and rate of complications; 10-12 points: high complexity and rate of complications.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.

**Fig. 1:** R.E.N.A.L. - Radius - A renal cell carcinoma measuring 31 mm: 1 point is given in this case.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 2:** R.E.N.A.L. - Exophytic/Endophytic: The lesion is < 50% exophytic : 2 points are given.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 3: R.E.N.A.L. - Nearness: The lesion is < 4mm away from the renal sinus: 3 points are given.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 4: R.E.N.A.L. - Anterior. (a) An axial line is drawn paralleling the renal hilum and bisecting the renal parenchyma. (b) With the cursor in the axial line scroll the cursor to the tumor. In this case the tumor is both anterior and posterior, so it is classified as "x".

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.

Fig. 5: R.E.N.A.L. - Location. (a) Inferior polar line. (b) Superior polar line. The tumor is above the superior polar line so 1 point is given.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 6: The RENAL index in this case is: $1 + 2 + 3 + 1 = 7x$, so the mass has moderate complexity and rate of complications.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 7: Another patient with renal tumor. Red line is axial midline and orange lines are polar lines. Arrow points out the renal tumor. The RENAL index in this case is \(2 + 1 + 3 + 3 = 10x\), so the mass has high complexity and rate of complications.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
<table>
<thead>
<tr>
<th></th>
<th>≤ 4 cm</th>
<th>1 point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 4 – 7 cm</td>
<td>2 points</td>
</tr>
<tr>
<td></td>
<td>&gt; 7 cm</td>
<td>3 points</td>
</tr>
<tr>
<td>Polar location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior/inferior</td>
<td></td>
<td>1 point</td>
</tr>
<tr>
<td>Middle</td>
<td></td>
<td>2 points</td>
</tr>
<tr>
<td>Exophytic/Endophytic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 50% exophytic</td>
<td></td>
<td>1 point</td>
</tr>
<tr>
<td>&lt; 50% exophytic</td>
<td></td>
<td>2 points</td>
</tr>
<tr>
<td>Totally endophytic</td>
<td></td>
<td>3 points</td>
</tr>
<tr>
<td>Renal rim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td>1 point</td>
</tr>
<tr>
<td>Medial</td>
<td></td>
<td>2 points</td>
</tr>
<tr>
<td>Renal sinus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not involved</td>
<td></td>
<td>1 point</td>
</tr>
<tr>
<td>Involved</td>
<td></td>
<td>2 points</td>
</tr>
<tr>
<td>Urinary collecting system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not involved</td>
<td></td>
<td>1 point</td>
</tr>
<tr>
<td>Dislocated/infiltrated</td>
<td></td>
<td>2 points</td>
</tr>
<tr>
<td>Face</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior (a)</td>
<td></td>
<td>No points given</td>
</tr>
<tr>
<td>Posterior (p)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5:** PADUA score: patients with scores of 8 or 9 have 14-fold higher risk of complications compared to those patients reporting scores of 6 to 7. Patients with a score >10 have a 30-fold higher risk of complications compared to those with scores of 6 or 7.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 8: P.A.D.U.A. - Size: Another renal cell carcinoma measuring 33 mm: 1 point is given.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 9: P.A.D.U.A. - Polar location: Inferior polar line. The tumor is bellow the inferior polar line so 1 point is given

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 10:** P.A.D.U.A. - Exophytic/Endophytic: The lesion is < 50% exophytic: 2 points are given. Also note that the lesion is in the medial rim, so 2 additional points are given.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 11:** P.A.D.U.A. - Renal sinus and collecting system involvement: The lesion (orange arrow) involves the renal sinus (yellow arrow) but not the collecting system (red arrow), so 2 + 1 points are given.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 12:** P.A.D.U.A. - Face: The lesion is anterior to the axial line so it is the classified as "a".

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 13: The PADUA index in this case is: $1 + 1 + 2 + 2 + 2 + 1 = 9a$, so the mass has 14-fold higher risk of complications compared to those patients reporting scores of 6 to 7.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 14: C - Index: The middle image was calculated and is number 33 (red arrow). In this image the central reference point was calculated as is seen in the image (orange arrow).

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 15:** C - Index: The hilar reference point (red arrow) was found as explained in the text.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 16:** C - Index: Image with the largest tumor diameter is image number 29. Distance y (cm): \((33 - 29)/ 6 = 0,66\)

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
**Fig. 17:** C - Index: Distance \( x \) is the distance between the hilar reference point and the center of tumor. The cursor was stabilized in the hilar reference point and scrolled until the large tumor image was found. Distance \( x \) calculated was 4.87 cm.

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Fig. 18: C - Index: The tumor diameter was calculated crossing a parallel line to the "x" line. Tumoral radius is 2,15 cm. The next step is calculating "c" distance: #(x²+y²) : #(4,872+0,662) = 5 . C-index (c/r) = 2,32

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Treatment suggestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – Axial tumor diameter</td>
<td></td>
</tr>
<tr>
<td>≥ 3cm</td>
<td>Consider cryoablation to reduce treatment failure</td>
</tr>
<tr>
<td>≥ 5cm</td>
<td>Consider preablation tumor embolization to reduce risk of bleeding complications</td>
</tr>
<tr>
<td>B – Bowel proximity</td>
<td>Patient reposition or bowel displacement maneuvers (pneumodisplacement or hydrodisplacement)</td>
</tr>
<tr>
<td>≤ 1 cm from the colon or small bowel</td>
<td></td>
</tr>
<tr>
<td>L – Location</td>
<td></td>
</tr>
<tr>
<td>Tumor in the anterior kidney</td>
<td>Hydrodisplacement (to protect adjacent bowel)</td>
</tr>
<tr>
<td>Tumor in the anterolateral upper pole</td>
<td>Transhepatic approach (to avoid traversing a large portion of normal kidney)</td>
</tr>
<tr>
<td>Tumor in anteromedial upper pole</td>
<td>Close blood pressure monitoring and consider preablation α-receptor blockade</td>
</tr>
<tr>
<td>Tumor in medial lower pole</td>
<td>Displacement techniques to protect nerves that pass along the psoas muscle</td>
</tr>
<tr>
<td>A – Adjacency to the ureter</td>
<td></td>
</tr>
<tr>
<td>≤ 1 cm from the ureter</td>
<td>Retrograde pyeloperfusion via an externalized ureteral stent or ureteral displacement</td>
</tr>
<tr>
<td>T – Touching renal sinus fat</td>
<td>Touched renal sinus fat</td>
</tr>
<tr>
<td>E – Endo/exophytic</td>
<td></td>
</tr>
<tr>
<td>Completely endophytic</td>
<td>Consider ultrasound or fusion guidance or administration of IV contrast for better lesion localization</td>
</tr>
</tbody>
</table>

**Table 6:** A.B.L.A.T.E. algorithm in patients being subjected to ablation therapies [13].

© Department of Radiology, Hospital São João, Medical Hospital of Porto, Portugal 2014.
Conclusion

The scope of this work is to call the attention of the radiologists to the need of being acquainted not only with the well widespread TNM staging system, but also with the new scoring systems, since their conjoint use is crucial to manage the best treatment approach of renal masses.

Since the advent of R.E.N.A.L., 3 more systems appeared and, although they have demonstrated to be reproducible inter-observer, they all have inherent strengths and weaknesses. Because some difficulties have been detected when applying the renal scores, new scoring systems are being developed in order to overcome those problems and to create more practical and simpler scores.
Personal information

Patricia Leitão

Department of Radiology, Hospital São João, Porto, Portugal

patleitao20@gmail.com
References


