Renal incidental findings on computed tomography

Frequency and distribution in a large non selected cohort

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Abstract
Renal incidental findings (IFs) are common. However, previous reports investigated renal IFs were limited to patient selection. The purpose of this study was to estimate the prevalence and distribution of all renal IFs on computed tomography (CT) in a large patient collective.

All patients, who underwent CT investigations of the abdominal region at our institution in the time period between January 2006 and February 2014 were included in this study. Inclusion criteria were as follows: no previous history of renal diseases and well image quality. Patients with known kidney disorders were excluded from the study. Overall, 7365 patients meet the inclusion criteria were identified. There were 2924 (39.7%) women and 4441 men (60.3%) with a mean age of 59.8±16.7 years. All CTs were retrospectively analyzed in consensus by 2 radiologists. Collected data were evaluated by means of descriptive statistics.

Overall, 2756 patients (37.42% of all included patients) showed 3425 different renal IFs (1.24 findings per patient). Of all renal IFs, 123 (3.6%) findings were clinically relevant, 259 (7.6%) were categorized as possibly clinically relevant, and 3043 (88.8%) were clinically non relevant.

Different renal IFs can be detected on CT. The present study provides a real prevalence and proportion of them in daily clinical routine. Kidneys should be thoroughly evaluated because of the fact that incidental renal findings occur frequently.

Abbreviations: CT = computed tomography, IF = incidental finding.

Keywords: CT, incidental findings, renal

1. Introduction
As incidental are findings defined that are not related to the scope of the ordered investigation.[1,2] According to the literature, incidental findings (IFs) are a frequent phenomenon and can be detected approximately in 70% of all imaging investigations.[1–3] Furthermore, the prevalence of IFs depends on the age, sex, and on the examined body region.[1–4] It has been shown that older patients had more IFs.[1–4] Furthermore, women tended to have more IFs than men.[1–4] In addition, pelvis more additional findings can be identified than in the head, neck, or thoracic regions.[1–4]

Most of IFs are clinically nonrelevant, such as degenerative spine changes, colonic diverticula, simple renal, or hepatic cysts.[3] However, also clinical significant IFs, for example, pulmonary embolism or malignant lesions have been described in the literature.[3,5–7]

As reported previously, renal IFs are common.[1,3,8,10] However, most of the previous reports investigated renal IFs were limited to patient selection.[8–18] For instance, the studies analyzed renal IFs in trauma patients,[13,14] renal donors,[15–17] patients underwent CT colonoscopy,[8–10], or in healthy persons.[18] In addition, the frequency of detected renal IFs was very variable in the reports.[8–18] Finally, some reports described selected renal findings.[11,12,17] So, Kim et al.[17] analyzed incidental renal stones only. To the best of our knowledge, there is no study, which analyses all renal IFs in a general clinical setting. Therefore, there are no statistical data regarding renal IFs in the real clinical practice.

Therefore, the aim of this study was to estimate the prevalence and distribution of renal IFs on computed tomography (CT) in a large patient collective.

2. Patients and methods
This study was approved from the institutional ethics board.

2.1. Patient collective
All patients, who underwent CT investigations of the abdominal region at our institution in the time period between January 2006 and February 2014 were included in this study. Inclusion criteria were as follows.
- No previous history of renal diseases;
- Well image quality.
Patients with known kidney disorders were excluded from the study. Overall, 7,365 patients met the inclusion criteria were identified (Fig. 1). There were 2,924 (39.7%) women and 4,441 men (60.3%) with a mean age of 59.8 ± 16.7 years, range 1 to 95 years.

2.2. Imaging technique

CT images were acquired using a CT-scanner (Somatom Sensation 64, Siemens, Erlangen, Germany). Typical imaging parameters were 120kVp, 150 to 300mAs, and 0.6 to 6mm slice thickness with a pitch of 0.6 to 1.0. Examined body regions were either thoraco-abdominal, abdominal, or whole body CT. In 5,892 patients (80% of all cases), 60 to 140mL of iodinated intravenous contrast medium was given at a rate of 1.5 to 3.5mL/s by a power injector (Medtron GmbH, Germany), with a scan delay of 30 to 90 seconds after onset of injection. In 1,473 patients (20% of the cases), CT investigations were acquired without intravenous administration of contrast medium.

2.3. CT indications

The indications for CT investigations were as follows: 4,569 (62.04%) thorax and abdominal CTs for evaluation/search of inflammatory focus; 1,678 (22.78%) CTs were performed for tumor search; 462 (6.27%) CTs were performed for trauma evaluation; 368 (5.00%) whole body CTs were performed as staging investigations in patients with known malignancies; finally, 288 (3.91%) angio-CTs were performed for vessel evaluation.

2.4. Image analysis

All CTs were retrospectively analyzed in consensus by 2 radiologists (D.S. and D.P.) with 4 and 1 year’s experience of CT, respectively. All images were studied in a digital format using a window of 56/342 on a PACS-workstation (Centricity PACS, GE Medical Systems, Milwaukee, WI). The identified renal IFs were classified according Lumbreras et al.[3] into major clinically relevant, moderate clinically relevant, and minor clinically relevant findings. Findings with major clinically relevance can change the clinical course of the patient, for example, a new found tumor, whereas minor clinically relevant findings don’t need any follow-up, for example, simple cysts. In the moderate clinically relevant group a diagnostic follow-up is recommended, but an immediate consequence for the patient is uncommon.[3] Renal cysts were classified according to Bosniak, which is widely used in clinical routine.[19]

2.5. Statistical analysis

Statistical analysis and graphics creation was performed using GraphPad Prism (GraphPad Software, La Jolla, CA). Collected data were evaluated by means of descriptive statistics (absolute and relative frequencies).

3. Results

Overall, 2,756 patients (37.42% of all included patients) showed 3,425 different renal IFs (1.24 findings per patient).

Renal cysts were the most common IF, followed by nephrolithiasis, and renal infarction (Table 1). Of all renal IFs, for tumor search; 462 (6.27%) CTs were performed for trauma evaluation; 368 (5.00%) whole body CTs were performed as staging investigations in patients with known malignancies; finally, 288 (3.91%) angio-CTs were performed for vessel evaluation.

| Diagnosis | n | Fraction of all patients with incidental findings n = 2,756 (%) | Fraction of all patients n = 7,365 (%) | Fraction of all findings n = 3,425 (%) |
|-----------|---|-------------------------------------------------------------|-------------------------------------|--------------------------------------|
| Malignant masses | 68 | 2.47 | 0.92 | 1.99 |
| Renal cell carcinoma | 30 | 1.09 | 0.41 | 0.88 |
| Renal metastasis | 29 | 1.05 | 0.39 | 0.85 |
| Lymphoma | 7 | 0.25 | 0.10 | 0.20 |
| Liposarcoma | 1 | 0.035 | 0.015 | 0.029 |
| Urothelial carcinoma | 1 | 0.035 | 0.015 | 0.029 |
| Benign masses | 48 | 1.74 | 0.65 | 1.40 |
| Angiomyolipoma/Angiolipoma | 43 | 1.56 | 0.58 | 1.26 |
| Oncocytoma | 4 | 0.15 | 0.05 | 0.12 |
| Leiomyoma | 1 | 0.035 | 0.015 | 0.029 |
| Renal cysts | 2,371 | 86.03 | 32.12 | 69.23 |
| Bosniak category I | 2,054 | 74.53 | 27.69 | 59.97 |
| Bosniak category II | 251 | 9.11 | 3.41 | 7.33 |
| Bosniak category IIF | 30 | 1.09 | 0.41 | 0.88 |
| Bosniak category III | 25 | 0.91 | 0.34 | 0.73 |
| Bosniak category IV | 11 | 0.40 | 0.15 | 0.32 |
| Non mass findings | | | | |
| Nephrolithiasis | 572 | 21.66 | 8.10 | 16.73 |
| Renal infarction | 105 | 3.81 | 1.43 | 3.07 |
| Atrophic kidneys | 80 | 2.90 | 1.09 | 2.34 |
| Parenchymal scarring | 74 | 2.69 | 1.00 | 2.16 |
| Abnormal position and development anomalies | 49 | 1.78 | 0.67 | 1.43 |
| Parenchymal calcifications | 30 | 3.7 | 1.38 | 0.88 |
| Pyelonephritis/abscess | 26 | 0.94 | 0.35 | 0.76 |
| Renal enlargement | 4 | 0.15 | 0.05 | 0.12 |
123 (3.6%) findings were clinically relevant, 259 (7.6%) were categorized as possibly clinically relevant and 3043 (88.8%) were clinically nonrelevant (Table 2).

The detected major clinically relevant findings are summarized in Table 3. There were renal cell carcinoma (n = 30, 24.39%), renal metastases (n = 29, 23.58%), renal cysts Bosniak category III (n = 25, 20.33%), and renal cysts Bosniak category IV (n = 11, 8.94%). Other relevant findings were rare. Of the diagnosed renal metastases, most arose from lung cancer, breast carcinoma, and malignant melanoma (Table 4).

Among the moderate clinically relevant findings, there were 131 cases with renal infarction (43.81% of all findings in this group), 47 atrophic kidneys (20.52%), 30 renal cysts Bosniak category IIF (13.1%), and 13 cases with angiomyolipoma (5.68%). Further findings are listed in Table 5.

In the minor clinically relevant group, most frequent finding were 2305 renal cysts Bosniak category I-IIe (75.74% of all findings in this group), followed by 572 cases with nephrolithiasis (18.8%), and 74 cases with renal scarring (2.43%). The detailed distribution of the findings is shown in Table 6.

Typical renal incidental findings of every group are shown in Figure 2.

4. Discussion

The present study provides frequency and distribution of renal IFs identified on CT. To the best of our knowledge, this is the largest patient collective to date.

There are numerous reports described several IFs on CT or MR images.[2–8,18] The frequency of renal IFs varied from 3.6% to 36.1% in different studies.[2,4,8–18] The analysis of the reported data shows that it depended on imaging modality and investigated collective.[8–18] So, Badiani et al[10] identified renal IFs in 18.9% of 1177 patients underwent CT colonoscopies. In the study of Ekeh et al[13] analyzed IFs in trauma patients, the prevalence of renal IFs was 36.1%. Lorenz et al[15] examined 1957 healthy renal donors and detected renal IFs in 21.4% of the cases. In angiographic CTs, Lindsay et al[20] showed renal IFs in 3.42% of 380 patients. Finally, in the population-based study of Health in Pomerania renal IFs were found in 5.28%.[18] As seen,

### Table 2
Incidental findings divided in groups of clinical relevance.

| Groups                      | n     | Fraction of all patients with incidental findings (%) | Fraction of all patients n=7,365 (%) | Fraction of all findings n=3,425 (%) |
|-----------------------------|-------|------------------------------------------------------|-------------------------------------|-------------------------------------|
| Major or clinical relevant  | 123   | 3.60                                                 | 1.67                                | 3.59                                |
| Moderate or possible relevant | 259   | 7.60                                                 | 3.52                                | 7.56                                |
| Minor or non relevant       | 3043  | 88.80                                                | 41.32                               | 88.85                                |

### Table 3
Clinically relevant findings. The findings represent 3.59% of the findings and 1.67% of the whole patient sample.

| Diagnosis                        | n     | Fraction of all clinically relevant findings (%) |
|----------------------------------|-------|--------------------------------------------------|
| Renal cell carcinoma             | 30    | 24.39                                            |
| Renal metastasis                 | 29    | 23.58                                            |
| Renal cyst Bosniak Category III  | 25    | 20.33                                            |
| Atrophic kidneys                 | 19    | 15.45                                            |
| Renal cyst Bosniak Category IV   | 11    | 8.94                                             |
| Lymphoma                         | 7     | 5.69                                             |
| Liposarcoma                      | 1     | 0.81                                             |
| Urothelial carcinoma             | 1     | 0.81                                             |
| Total                            | 123   | 100                                              |

### Table 4
Primary tumors of renal metastases.

| Presumably primary tumor | n (%  ) |
|-------------------------|---------|
| Lung cancer             | 8 (27.59) |
| Breast cancer           | 7 (24.14) |
| Malignant melanoma      | 4 (13.79) |
| Prostate cancer         | 2 (6.9)  |
| Cancer of unknown primary | 2 (6.9) |
| Squamous cell carcinoma | 2 (6.9)  |
| Leiomyosarcoma           | 2 (6.9)  |
| Thyroid cancer           | 1 (3.45) |
| Carcinoma of the urinary bladder | 1 (3.45) |
| Total                   | 29 (100%) |

### Table 5
Moderate or possible clinically relevant findings. The findings represent 7.6% of the findings and 3.5% regarding the whole patient sample.

| Diagnosis                        | n     | Fraction of all possible clinically relevant findings (%) |
|----------------------------------|-------|----------------------------------------------------------|
| Renal infarction                 | 105   | 40.54                                                    |
| Atrophic kidney                  | 47    | 18.15                                                    |
| Angiomyolipoma/Angiolipoma       | 43    | 16.60                                                    |
| Renal cyst Bosniak category IIF  | 30    | 11.58                                                    |
| Pyelonephritis                   | 26    | 10.04                                                    |
| Oncocytoma                       | 4     | 1.54                                                     |
| Renal agenesis                   | 2     | 0.77                                                     |
| Leiomyoma                        | 1     | 0.39                                                     |
| Polycystic kidneys               | 1     | 0.39                                                     |
| Total                            | 259   | 100                                                      |

### Table 6
Minor or clinically nonrelevant findings. The findings represent 88.8% of the findings and 41.32% regarding the whole patient sample.

| Diagnosis                        | n     | Fraction of all clinically not relevant findings (%) |
|----------------------------------|-------|------------------------------------------------------|
| Renal cyst Bosniak Category I    | 2054  | 67.50                                                |
| Nephrolithiasis                  | 572   | 18.80                                                |
| Renal cyst Bosniak Category IIA-IE | 251  | 8.25                                                |
| Renal parenchymal scarring       | 74    | 2.43                                                 |
| Abnormal position                | 47    | 1.54                                                 |
| Parenchymal calcifications        | 30    | 0.99                                                 |
| Other parenchymal abnormalities  | 15    | 0.49                                                 |
| Total                            | 3043  | 100                                                   |
the reported data showed the frequency of renal IFs in selected cohorts or in a general health population and did not give a real percentage of renal findings in a clinical practice.

Furthermore, also in similar modalities and patients the reported prevalence of renal IFs ranged significantly. For instance, in trauma patients, Hoffstetter et al. identified renal IFs in 6.9% and in the study of Ekeh et al. they were described in 36.1% of the investigated patients. This discrepancy is difficult to ascertain and may be related to different data acquisition.

In contrast to previous reports, in the present study all patients without known history of kidney disorders investigated by CT were included into the analysis. Therefore, our data represent a true clinical situation and provide real frequency and distribution of renal IFs in a large hospital collective. As seen, renal IFs occur in 37.42% of all analyzed patients. It is more than in most previous reports and is related to the fact that we acquired all renal IFs.

Similar to the prevalence, also the spectrum of renal IFs is different in the literature. Most frequently, several benign disorders, such as simple renal cysts, renal scars or stones occurred. However, the proportion of the findings was very variable. For example, Hoffstetter et al. found renal cell carcinoma in 0.33% of all analyzed patients, complicated cysts in 1.97%, and simple cysts in 4.61%. Similar results were reported by Naidu et al. In another study, significant renal IFs, such as renal cell carcinoma, angiomylipoma and hydronephrosis were identified in 1.9% of investigated cases and the frequency of renal cell carcinoma was 0.51%. Additionally, non significant renal IFs were detected in 17%. Gluecker et al. found a higher proportion of relevant findings, namely 5%. Furthermore, moderate and renal IFs of low relevance were identified in 9.7% and 8.2% of the cases, respectively. However, Lorenz et al. did not find any cases of renal cancer in their sample of 1957 patients. In addition, some studies did not itemize their findings. Especially, cystic lesions were often as “cysts” categorized. However, it is well known that there are different renal cystic lesions with different behavior and clinical relevance.

In the present study, 3.6% of renal IFs were clinically relevant. This accounted 1.67% of all patients investigated by CT. In addition, the frequency of all malignant findings renal cell carcinoma was 0.92% of all included patients. This finding is very important and represents a frequency of incidental renal malignancies in a hospital collective underwent CT investigation. Most malignancies were renal cell carcinomas. According to the literature, over 60% of cases with renal cell carcinomas are clinically silent and commonly detected incidentally. Therefore, kidneys should be thoroughly evaluated by CT.

Renal metastases were second malignant relevant finding in our study. As reported previously, this entity is asymptomatic and more often is identified on imaging. Most frequently, lung cancer, breast carcinoma, and malignant melanoma metastasize into the kidney. Renal metastases are more often small multiple masses and show an exophytic growth in comparison to the renal cell carcinoma, even though a certain diagnostic discrimination is not possible on CT. Our findings are in agreement with the literature. Other malignant lesions were rare. Other significant findings were complex renal cysts Bosniak III and IV, which occurred in 0.34% and 0.15% of all patients, respectively. It is very important to precisely classify renal cysts, especially Bosniak category IV because of the fact that they are malignant lesions.

Possible relevant findings in our study were identified in 3.5% of the 7365 analyzed cases and accounted 7.6% of all identified renal IFs. It is more than reported previously. Most frequently, renal infarction, parenchyma atrophy, signs of pyelonephritis, and angiomylipomas occurred.

Most of all detected renal IFs (88.8%) were clinically nonrelevant. In agreement with previous reports, more often renal cysts Bosniak category I-IIe, followed by renal stones and
scars occurred. However, in comparison to reported data, in the present study, the number of low relevant findings was significant higher. So, Gluecker et al.[8] reported the frequency of low relevant renal IFs as 8.22% of all investigated patients. In another study, it was 16.99%.[11] In the present study, the frequency of this subgroup of findings was 41.32% of all included patients.

Furthermore, most authors did not provide a detailed description of low relevant findings.

Overall, our study demonstrated that different renal IFs can be detected on CT. Furthermore, it provides a real prevalence and proportion of them in daily clinical routine. Additionally, 3.6% of the detected IFs were clinically relevant, that is, they could change the general clinical situation in these cases.

Our study had several limitations. Firstly, this is a retrospective single center study. Secondly, there might be a patient bias. However, this patient sample was investigated in a representative university hospital and our results can be applied to other medical centers.

5. Conclusion
Regardless of the initial CT indication, kidneys should be thoroughly evaluated because of the fact that incidental renal findings occur frequently. Although most of them are not of clinical relevance, some findings might require closer work up and adjustments in clinical management of the patient.

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