Striated Nephrogram as an Incidental Finding in MRI Examination of Children

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Key words
- abdomen
- contrast agents
- MR-imaging

Abstract

Purpose: A highly striated contrast pattern of the kidneys occasionally appears in abdominal MRI examinations of children following the administration of gadolinium. As this phenomenon is well known but has not yet been explicitly described in literature, we investigated how frequently and in which clinical context this occurred.

Material and Methods: 855 abdominal MRI examinations with contrast media of 362 children between 2006 and 2014 were analysed retrospectively.

Results: A striated renal parenchyma was found in a total of nine children and eleven examinations (1.3 % of examinations) and did only occur at a field strength of 3 Tesla. Of these children, seven had previously had tumors and chemotherapy. In two children there was no evidence of a previously serious condition with medications or a kidney disease. All of them had a normal renal function.

Conclusion: A noticeably striated nephrogram in the later phase of an MRI examination following administration of gadolinium may appear as an incidental finding in examinations at 3 Tesla without pathological relevance.

Key points:
- striated nephrograms may appear at a field strength of 3 Tesla.
- incidental finding without pathological relevance.

Introduction

Contrast-enhanced abdominal MRI is routinely used in diagnosing pediatric patients with all types of abdominal diseases. It is
used in particular in the diagnosis and follow-up of both
tumors and non-malignant diseases.
The cortical region of the renal parenchyma generally exhib-
tes homogenous contrast following the administration of
gadolinium. In individual cases, however, we have inciden-
tially observed an unusual striated image in late phase
contrast-enhanced images. As this phenomenon has not
yet been explicitly described in scientific MRI literature,
this retrospective article examines how frequently and in
which clinical context striated MRI nephrograms appear in
pediatric cases.

Material and methods ▼

Altogether, 855 contrast-enhanced MRIs performed over
362 patients (180 females, 182 males, ages 0 – 18) between
July 2006 and May 204 were evaluated. Of the 362 pa-
tients, 136 were examined for suspected tumors or to eval-
uate the course of known tumors, accounting for a total of
565 of the 855 examinations. The examinations were per-
formed on a 1.5- (Intera, Philips; Amsterdam, Netherlands)
and a 3-Tesla machine (Siemens Trio, Siemens Healthcare,
Erlangen, Germany) using the contrast medium Omnis-
can® (GE Healthcare, Chalfont St Giles, U.K.), Dotarem®
(Guerbet, Villepinte, France), Gadovist® (Bayer Schering
Pharma AG, Berlin, Germany) und Multihance® (Bracco Di-
agnostics, Milan, Italy), which were administered intrave-
rously according to weight (0.2 ml per kg of body weight)
(or 0.1 ml per kg of body weight in the case of Gadovist).
Depending on the clinical objective, either dynamic or
non-dynamic sequences were performed following the ad-
ministration of contrast agent. If a striated nephrogram
was yielded, the following information was documented
in addition to the underlying disease: the current medical
history, the glomerular filtration rate (based on plasma
creatine using the Schwartz formula) as kidney function
marker, the contrast medium used and the respective
dose as well as the time between administering contrast
medium and the appearance of the striated nephrogram.
All examinations were evaluated by a radiologist (S.S.)
with four years' experience in MRI. Positive reports were
evaluated by a second radiologist (F.W.H.) with 20 years'
experience. If there was a discrepancy between the radiol-
ogists’ evaluations, final assessment was reached through
consensus.

Results ▼

A striated nephrogram was found in a total of 9 patients
( Table 1 ), 5 males and 4 females, and in 11 examinations
(3 positives for 1 patient), corresponding to a frequency of
1.3 % ( Fig. 1, 2 ). The patients were children with different
underlying diseases: 7 children were undergoing tumor
assessment following chemotherapy (5 neuroblastomas
as well as 1 contralateral nephroblastoma), accounting for
1.1 % of all abdominal MRI examinations following admin-
istration of contrast medium. At the time of examination,
two of these patients were in the midst of ongoing chem-
otherapy. For the remaining patients, the time span be-
tween their last chemotherapy and the MRI ranged be-
tween 7 months and 4 years. In addition, two of the
children exhibiting remarkable nephrograms had no prior
tumors and had not received chemotherapy or any other
type of long-term therapy. One child had a venous malfor-
mation, while the other had a hepatic cyst. This accounted
for 0.2 % of all abdominal MRI examinations following ad-
ministration of contrast medium.

At the time of examination, none of our patients exhibited
impaired kidney function in terms of estimated glomeru-
lar filtration rate or infectious kidney disease.
The span of time between the administration of contrast
medium and the appearance of the striated nephrogram
ranged between 9 and 38 minutes with a median of 17.5
minutes. The contrast medium Dotarem® (Guerbet, Ville-
pinte, France), was administered for 7 patients, Omniscan®
(GE Healthcare, Chalfont St Giles, UK) for 1 patient and Ga-
dovist® (Bayer Schering Pharma AG, Berlin, Germany) for 1
patient as well, with Dotarem being used for a total of 512,
Multihance for 30, Omniscan for 98 and Gadovist for 215
examinations. All striated nephrograms were observed ex-
clusively with examinations performed on the 3-Tesla ma-
chine (Siemens Trio, Siemens Healthcare, Erlangen, Ger-
many), which was used for 578 of the 855 examinations.

Discussion ▼

Changes in the renal parenchyma, which normally exhibits
homogenous contrast, have been described following the
administration of contrast medium in CT examinations
for various kidney diseases [1]. This unilateral or bilateral
striated nephrogram seen on CT has been attributed to ob-

Table 1 Patients with striated nephrogram.

<table>
<thead>
<tr>
<th>pat. no.</th>
<th>age [in years]</th>
<th>underlying disease</th>
<th>kidney function and urine status</th>
<th>time following administration of contrast medium [in minutes]</th>
<th>contrast medium and dosage [in ml]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>neuroblastoma stage I</td>
<td>n.p.</td>
<td>10</td>
<td>Dotarem; 4</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>neuroblastoma stage IV</td>
<td>n.p.</td>
<td>16</td>
<td>Dotarem; 3</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>neuroblastoma stage I</td>
<td>n.p.</td>
<td>29</td>
<td>Dotarem; 4</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>hepatic cyst</td>
<td>n.p.</td>
<td>13</td>
<td>Dotarem; 2</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>nephroblastoma</td>
<td>n.p.</td>
<td>38, 9, 13</td>
<td>Dotarem; 6</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>neuroblastoma stage IV</td>
<td>n.p.</td>
<td>11</td>
<td>Omniscan; 15</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>neuroblastoma stage IV</td>
<td>n.p.</td>
<td>23</td>
<td>Dotarem; 4</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>venous malformation</td>
<td>n.p.</td>
<td>15</td>
<td>Dotarem; 4</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>hepatoblastoma</td>
<td>n.p.</td>
<td>16</td>
<td>Gadovist; 2</td>
</tr>
</tbody>
</table>

Pat. no. = patient number, min = minutes, ml = milliliter, n.p. = not pathological.

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structive uropathy as well as renal vein thrombosis, trauma, arterial hypotension and acute cases of pyelonephritis [1]. In terms of their etiology, these changes in nephrogram involving remarkable striation following the administration of contrast medium were associated with a displacement of the renal tubules, e.g. resulting from the precipitation of proteins, with this finding initially being described in 1971 among patients with multiple myeloma [2]. However, other substrates such as, for example, Tamm-Horsfall-proteins, uric acid, myoglobin in the case of rhabdomyolysis or dehydration have also been accepted as causal [1, 3–6], a displacement of the tubules with consecutive stasis of the contrast medium having been discussed on the etiopathological level as a cause of the appearance of a striated nephrogram. Although these striated signal decreases in MR nephrograms are likewise familiar to several radiologists, this phenomenon has not yet been addressed in scientific radiological literature on magnetic resonance imaging. Because it was remarkable that there was a relatively long span of time between contrast medium being applied and the striated nephrogram appearing, the author’s posit that the striated, signal-free zones in the renal parenchyma are possibly an accumulation of contrast medium and a contrast inversion resulting from an intensified T2 shortening effect when a very high gadolinium concentration is present, with the striated appearance being explained by the tubular structure of the tubules as they run from the renal cortex to the renal papilla. This phenomenon observed more frequently in patients following chemotherapy may be caused by a stasis of the contrast medium in the tubules following prior chemotherapy, e.g. through damage thereto or through intraluminal deposits. However, because the same phenomenon was also visible in two cases in which we were unable to see a causal connection to a prior or acute disease, the striated nephrogram may also constitute an incidental, non-pathological finding in these cases. Supporting a non-pathological finding are also the facts that the striated nephrograms yielded for the patients in question were not replicated in the subsequent follow-up examinations and that the phenomenon appeared only in examinations performed on the 3-Tesla machine, implying a dependency on field strength. Arguing against this are the results of Trout et al. [7], who examined the same phenomenon and demonstrated an association between the appearance of a striated nephrogram and a specific MR scanner regardless of field strength. However, this study likewise concedes an absent causal pathology. One limitation of the present study is that it is a retrospective assessment, thus meaning that the follow-up observation period was not of comparable length for all patients. If comparably long follow-up observation periods were employed, it would have to be assumed that the incidence of this incidental finding could increase. Another limitation was that different MR contrast media and non-uniform examination protocols were used.

**Conclusion**

Unlike in CT examinations, where it has been described only in connection with an underlying pathology, a remarkable striated nephrogram in the late phase of an MRI examination following the administration of contrast medium appears to occur as an incidental finding following the intravenous administration of contrast medium and presumably involves an intensified T2 shortening effect resulting from a high concentration of contrast media in the renal tubules, which is demonstrated particularly at a field strength of 3 Tesla, with presumably no pathological significance being attached to this finding.
References

4 Martin DJ, Jaffe N. Prolonged nephrogram due to hyperuricemia. Br J Radiol 1971; 44: 806–809