Comparative Study of Renal Uptake of some Radiopharmaceuticals in Static and Dynamic Renography


Abstract—Renography has been used to measure the renal function for a long time. It is a form of medical imaging of the kidneys that uses radio-labelled pharmaceuticals. There are different radiopharmaceuticals used in renography such as technetium-99m dimercaptosuccinic acid (Tc-99m DMSA), technetium-99m diethylenetriamine pentaacetic acid (Tc-99m DTPA), technetium-99m mercaptoacetyltriglycine (Tc-99m MAG3), iodine 131 orthiodohippurate (OIH) and technetium-99m ethlenedicycisteine (Tc-99m EC). The aim of this study is to compare the split renal function (SRF) measured by Tc-99m DTPA and Tc-99m MAG3 dynamic renography and the renal uptake% values measured by Tc-99m DMSA static renal scan. 78 subjects in this study were divided into two groups. Group 1 consists of 25 subjects (14 males and 11 females with age ranging from 3months to 70 years; mean age 54.23 years old) and Group 2 consists of 53 subjects (33 males and 20 females with age ranging from 1 to 72 years; mean age 31.17 years old). Both Tc-99m DTPA and Tc-99m DMSA renal scintographies were performed in Group 1, Tc-99m MAG3 and Tc-99m DMSA renal scintographies were performed in Group 2. Imagings has been done 2 hours following intravenous injection of 99m Tc-DMSA or immediately after administration of Tc-99m DTPA and Tc-99m MAG3. SRF values calculated by Tc-99m DTPA and Tc-99m MAG3 dynamic renography were statistically compared with renal uptake% values calculated by Tc-99m DMSA static renal scan. The results obtained in Group 1 showed that SRF values(mean±sd) % of left and right kidneys measured by Tc-99m DTPA renography were 46.20 ± 20.39%, 53.79 ± 20.39%, respectively and the renal uptake% values(mean±sd)% of left and right kidneys measured by Tc-99m DMSA renal scan were 45.85 ± 18.81%, 54.15 ± 18.81%, respectively. The results obtained in Group 2 showed that SRF values(mean±sd) % of left and right kidneys measured by Tc-99m MAG3 renography were 49.7 ± 17.72%, 50.29 ± 17.72%, respectively and the renal uptake% values(mean±sd)% of left and right kidneys measured by Tc-99m DMSA renal scan were 50.09 ± 17.32%, 49.91% ± 17.32%, respectively. In conclusions the split renal function values measured by Tc-99m DTPA and Tc-99m MAG3 dynamic renography is not statistically different from renal uptake%values measured by Tc-99m DMSA static renal scan (p=0.737, p=0.999, respectively). A p value less than .05 was considered significant. Also the results showed that Tc-99m DMSA is more agreed with Tc-99m MAG3 than Tc-99m DTPA, so Tc-99m MAG3 is preferred as it gives better information about both the structure of renal parenchyma and kidney functions. SRF values obtained from MAG3 and DTPA radiopharmaceuticals are reliable although that DMSA is considered as the most reliable radiopharmaceutical used in the measurements of renal uptake. So it is possible to use one of these techniques for determination of split renal function or renal uptake.

Index Terms—split renal function, renal uptake%, Tc-99m DMSA, Tc-99m DTPA, Tc-99m MAG3.

1 INTRODUCTION

Renal studies using radiopharmaceuticals (renography) have been used for a long time to estimate renal functions [1], [2]. This made renal scintigraphy to be one of the most useful tools in nuclear medicine [3], [4]. Renography can be performed using different radiopharmaceuticals such as technetium-99m dimercaptosuccinic acid (99m-Tc DMSA), technetium-99m diethylenetriamine pentaacetic acids (99m-Tc DTPA), technetium-99m mercaptoacetyltriglycine (99m-Tc MAG3), iodine 131 orthiodohippurate (OIH) and technetium-99m ethlenedicycisteine (99m-Tc EC) [5].

Renal functions such as split renal function (SRF), differential renal function and relative renal function can be expressed as a percent of total renal function [2]. 99m-Tc DMSA, Tc-99m DTPA and 99m-Tc MAG3 have different renal uptakes mechanisms, so they can be used to compare the relative renal uptakes [6]. The quantification of renal uptake with radionuclide studies is simple and non-invasive way to assess renal function [7]. 99m-Tc DMSA was introduced in the early 1970 [8],[9]. Ever since, 99m-Tc DMSA as static renal radiopharmaceutical is considered the most reliable method used in measuring parenchymal function of the kidneys, pyelonephritis, renal scarring and functional renal mass [10], [11], [12], [13]. And also calculating differential, individual and absolute renal function [14], [15]. Tc-99m DMSA has been the most appropriate tracer for high resolution imaging of renal cortex [16]. Tc-99m DTPA is a radiopharmaceutical that is freely filterable at the glomerulus. It is used for measuring glomerular filtration rate (GFR) for each kidney [17] and also can be used to measure total and individual renal function [2] using the gamma camera technique. 99m-Tc MAG3 is a tubular excreted radiopharmaceutical that is used for measuring effective renal...
plasma flow (ERPF) for each kidney and also can be used for measuring kidney functions using gamma camera [2], [6]. Tc-99m EC radiopharmaceutical has been developed to perform dynamic renography and to measure relative renal function [18]. This study aimed to compare the split renal function values calculated from 99m-Tc DTPA and Tc-99m MAG3 dynamic renography with the renal uptake values calculated from 99m-Tc DMSA static renography.

2 SUBJECT AND METHOD

This study include 78 subjects (47 males and 31 females) ranging in age from 3 months to 72 years who were referred to the urology and nephrology centre at Mansoura University for routine indications, such as estimation of renal functions and pathophysiology, etc during 2014 to 2016. A total 78 subjects were divided into two separate groups. Group 1 consists of 25 subjects (14 males and 11 females; mean age 54.23 years old) who done dynamic renography using 99m-Tc DTPA and static renal scan using 99m-Tc DMSA. Group 2 consists of 53 subjects (33 males and 20 females; mean age 31.17 years old) who done both the dynamic renography using 99m-Tc MAG3 and the static renal scan with 99m-Tc DMSA. In all cases of the two groups, there are a variety of clinical diagnoses such as hydronephrosis, pyelonephritis, kidney obstruction, polycystic kidney, pyelonephritic with hydronephrosis and reduced renal function. Both dynamic and static renal images were acquired with the patients in a supine position to minimize renal depth and reduce movement. and with gamma camera’s detector placed in posterior view; ideally the renal area should be in the center of the field of view. All studies were done using an BRIGHT VIEW (PHLIPS) gamma camera attached to a monitor PHILIPS computer with double head detector, low energy, high resolution and parallel hole collimator.

All information about patient such as weight, height, age and clinical information was recorded. The patients were hydrated with 500ml of water 20-30 min prior to radiopharmaceuticals injection then the bladder emptied before examination. 99m-Tc DMSA static renography with was carried out on all patients. In 99m-Tc DMSA static renal scan, patients were injected intravenously with dosage ranging from 0.5-3mCi and static images were acquired 2 hour following tracer administration at the anterior, posterior and posterior oblique projections then the renal uptake % values were calculated. Poor renal absorption of 99m-Tc DMSA may be observed on some patients with advanced renal failure. it is reported that an image at sufficient level can be obtained in delayed time up of 24 hours on these patients. Dynamic renography with 99m-Tc DTPA and 99m-Tc MAG3 was carried out on 25, 53 patients respectively. In dynamic renography using 99m-Tc DTPA and 99m-Tc MAG3, patients were injected intravenously of dosage ranging from 0.5-5mCi and furosemide was given 3 minutes following tracer administration, the dose of furosemide was 0.5 mg/kg body weight. Dynamic imaging was performed within 20 minutes in the posterior projection.

3 RESULTS

The results of the renal uptakes for 78 patients classified into two separate groups were calculated and compared by the Statistical package for the social sciences, version 20 (SPSS software). The results of the average split renal function and standard deviation values for right and left kidneys obtained from 99m-Tc DTPA and 99m-Tc MAG3 dynamic renography were compared with the average renal uptakes and standard deviation values for right and left kidneys obtained from 99m-Tc DMSA static renal scan. The results are tabulated in table 1 and 2.

Two examples for two cases who done both dynamic renography and static renal scan were illustrated in figure 1(a, b) and figure 2(a, b).

Table 1. the mean split renal function values obtained from 99m-Tc DTPA and the mean split uptakes values obtained from 99m-Tc DMSA.

<table>
<thead>
<tr>
<th>Method</th>
<th>Left kidney</th>
<th>right kidney</th>
<th>Mean ± SD %</th>
<th>Mean ± SD%</th>
</tr>
</thead>
<tbody>
<tr>
<td>99m-Tc DMSA</td>
<td>45.85±18.81</td>
<td>54.15±18.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99m-Tc DTPA</td>
<td>46.20±20.39</td>
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<td></td>
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</tr>
</tbody>
</table>

Table 2. the mean split renal function values obtained from 99m-Tc MAG3 and the mean uptakes values obtained from 99m-Tc DMSA.

<table>
<thead>
<tr>
<th>Method</th>
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<th>Mean ± SD %</th>
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</tr>
</thead>
<tbody>
<tr>
<td>99m-Tc DMSA</td>
<td>50.09±17.32</td>
<td>50.91±17.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99m-Tc MAG3</td>
<td>49.7±17.72</td>
<td>50.29±17.72</td>
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</tbody>
</table>

There was no statistically significant difference between the split renal function values measured with either 99m-Tc DTPA or 99m-Tc MAG3 dynamic renography and the renal uptake values obtained from 99m-Tc DMSA static renal scan. (p=0.737, p=0.999, respectively).
Figure 1(a, b) show both dynamic renography with Tc-99m DTPA and static renal scan with $^{99m}$Tc DMSA respectively for one of the cases.

Figure 2(a, b) show both dynamic renography with Tc-99m MAG3 and static renal scan with $^{99m}$Tc DMSA respectively for one of the cases.
4 Discussion

There are more radiopharmaceuticals that can be used in renography such as Tc-99m DMSA for static (cortical) renography and 99m-Tc DTPA, Tc-99m MAG3, 99m-Tc EC and iodine 131 orthiodihippurate for dynamic renography. [5] 99m-Tc DMSA is used for scintigraphic diagnosis of the following renal disorders by nuclear medicine specialists; morphological analysis of renal cortex, analysis of each renal function, ectopic renal location. 99m-Tc DMSA static renography has been considered the best method for estimation SRF because 99m-Tc DMSA enter the proximal tubular cell and largely bound to serum protein which makes enough long time to allow static imaging of tubular activity over several minutes.[2],[15],[19] Parenchymal function of the kidneys can be determined by using 99m-Tc DMSA static renography, both quantitatively and visually and also absolute and differential renal function can be calculated.[14],[15]

These functions can also be estimated by means of dynamic renography as well as 99m-Tc DMSA static renography. Dynamic imaging with 99m-Tc DTPA or 99m-Tc MAG3 which has been taken in the first several minutes usually takes 20 to 30 min and reflects differential renal function (uptake). [20],[21] 99m-Tc DTPA and 99m-Tc MAG3 are used for examinations of kidneys by dynamic scintigraphy, quantitative determination of tubular extraction rate and for separated examinations of function of one kidney.

In the previous studies, there is no clinical significant difference between differential function values obtained from 99m-Tc DMSA and 99m-Tc MAG3 renal scintigraphy. Also the studies showed that 99m-Tc MAG3 able to detect parenchymal damage [22],[23]. Another studies showed that there is a high correlation between 99m-Tc EC and 99m-Tc DMSA renal scintigraphy in terms of relative renal function. [24],[25] Domigues et al. (2006) compared relative renal function values calculated by either 99m-Tc EC or 99m-Tc DTPA dynamic renography with that calculated by 99m-Tc DMSA static renography. They noticed significant difference between 99m-Tc DTPA and 99m-Tc DMSA renal scintigraphy and no statistically difference between 99m-Tc EC and 99m-Tc DMSA renal scintigraphy. [26]

In an experimental study in rabbits, renal function values using 99m-Tc DTPA and 99m-Tc MAG3 dynamic renal scintigraphy were compared to those obtained using 99m-Tc DMSA static renal scintigraphy. There was no significant difference between these methods and it was confirmed that 99m-Tc DMSA renography can be replaced by 99m-Tc DTPA or 99m-Tc MAG3 renography to determine differential renal function. [6]

In another study, Dostbil et al. (2011) found that SRF values estimated by 99m-Tc DTPA and 99m-Tc MAG3 dynamic renal scintigraphy were not statistically different with that values obtained by 99m-Tc DMSA static renal scintigraphy.[2]

In another study, 99m-Tc DTPA and 99m-Tc MAG3 renal scintigraphy were compared with 99m-Tc DMSA renal scintigraphy in terms of DRF, this study showed that there is no significant difference between these methods. [27] In our study, renal uptakes of 99m-Tc DTPA, 99m-Tc MAG3 and 99m-Tc DMSA radiopharmaceuticals were compared and results showed that there is no statistical difference.

5 CONCLUSION

The split renal function values measured by Tc-99m DTPA and 99m-Tc MAG3 dynamic renography is not statistically different from renal uptake%values measured by Tc-99m DMSA static renal scan (p=0.737, p=0.999, respectively). A p value less than .05 was considered significant. Also the results showed that 99m-Tc DMSA is more agreed with Tc-99m MAG3 than 99m-Tc DTPA, so 99m-Tc MAG3 is preferred as it gives better information about both the structure of renal parenchyma and kidney functions. SRF values obtained from MAG3 and DTPA radiopharmaceuticals are reliable although that DMSA is considered as the most reliable radiopharmaceutical used in the measurements of renal uptake. So it is possible to use one of these techniques for determination of split renal function or renal uptake.

REFERENCES

[11] Piepsz A: Cortical scintigraphy and urinary tract infection in chil-


