CHAPTER –III

ESTIMATED GFR (eGFR) FOR THE ASSESSMENT OF CKD

3.1 INTRODUCTION

Chronic Kidney Disease (CKD) classification is a major step which is done by quantifying the glomerular filtration. Glomerular Filtration Rate (GFR) will assess the filtering capacity of nephrons in the kidney (Graham et al., 2003). It is an index for renal function and without an awareness of GFR, the clinical features in CKD may remain silent and deceptive (Dalton, 2010). GFR is helpful for early detection of renal impairment and is a good indicator to assess the need for dialysis. The K/DOQI classified CKD patients based on GFR into five stages. They are stage 1 (GFR ≥ 90 ml/min/1.73 m²), stage 2 (GFR 60 to 89 ml/min/1.73 m²), stage 3 (GFR 30 to 59 ml/min/1.73 m²), stage 4 (GFR 15 to 29 ml/min/1.73 m²) and stage 5 (GFR less than 15 ml/min/1.73 m²) (National Kidney Foundation 2002).

CKD staging and thereby, assessment of renal function is helpful for clinicians for proper diagnosis and to undertake suitable therapeutic measures. After thirty years, GFR starts declining around 0.75 ml/min/year in normal people (Lindeman et al., 1985 and Puyol, 1998). It may be further decreased in older age. This may be due to either physiological or pathological processes which include a decline in the vascular elasticity of kidneys with ageing (Benetos et al., 2002), besides diabetes and hypertension which are common associations during senescence (Dharmarajan et al., 2003).

Gold standards for GFR assessment employ inulin and radiolabeled substances but both of them are not free of adverse effects and hence do not constitute routine investigations. Estimation of serum creatinine is simple method and commonly used for estimation of GFR. However, serum creatinine based GFR has its own drawbacks such as tubular secretion of creatinine, variation of serum creatinine from individual to individual based on muscle mass and additionally, it varies with the assay procedure. Besides this, any significant rise of serum creatinine reflects a fall of about
50% of GFR. In spite of these shortcomings of serum creatinine it is an indicator for CKD, and still serves as an acceptable parameter for diagnosis of CKD in clinical practice (Graham et al., 2003). Measured Creatinine clearance for 24 hours urine has its own disadvantages as it will not be possible to collect accurate 24 hour urine in older people and dialysis patients (Stevens et al., 2006)

Measuring GFR can be done by employing different equations using serum creatinine. These methods are simple, cost effective and less time consuming (Menon et. al., 2007). The most common formulae are Cockcroft-Gault formula (CG) (Cockcroft and Gault 1976) and Modification of Diet in Renal Disease (MDRD) (Levey et al., 2000) and Mayo Clinic Quadratic Equation (MCQE) (Rule et al., 2004) as an alternative. MDRD and MCQE are based on clearance of I\textsuperscript{125} iothalamate whereas CG is based on the creatinine clearance. These three formulae too have their own limitations.

The current study was undertaken to estimate and compare the CG, MDRD and MCQE equations in assessing the GFR in control and CKD groups.

3.2 MATERIALS AND METHODS

3.2.1 Selection of Cases
A total of 128 patients with evidence of CKD were taken as cases. These patients were admitted into Nephrology unit of MIMS hospital, Nellimarla. The CKD cases included both nondialysis group and hemodialysis group. They were included in the study on the basis of clinical signs and symptoms of kidney disease along with elevated blood urea and serum creatinine levels. The hemodialysis patients were undergoing hemodialysis in Nephrology department, 3 to 4 hours per day, 2-3 times in a week for the past 6 months to 3 years, and nondialysis patients were under conservative medical therapy.

Inclusion criteria: Diagnosed cases of CKD both nondialysis and hemodialysis

Exclusion criteria: Patients with Viral hepatitis, HIV positive, Cancer, Myocardial infarction.
3.2.2 Selection of control
Control group comprised of 123 age and sex matched healthy individuals who were free of features of kidney disease and were having a normal blood urea and serum creatinine level. The upper limit for serum creatinine levels was 1.2 mg/dl and the corresponding value for blood urea was 45 mg/dl. Individuals suffering from diseases that are likely to alter these parameters were excluded from the study. Likewise, persons with history of drug intake which cause changes in these parameters were also excluded.

Ethical committee approval was obtained from Maharajah’s Institute of Medical Sciences. Informed consent was taken from the patients and controls who participated in the present study. Patients were informed the importance of the study, procedures to be performed and benefits of the study.

3.2.3 Demographic parameters
In all the subjects, Height was measured in centimetres and Weight was recorded in kilogram on standard clinical weighing machine. BMI was calculated as Weight in kilogram divided by Height in meters squared. Based on BMI they were categorized as underweight (<18.4), normal (18.5-22.9), overweight (23-24.9) and obese (>25). Individuals with a BMI of 25 to 29.9 were regarded as mildly obese whereas those with a BMI exceeding 30 were considered as moderately obese. Moderately obese subjects were excluded from the study.

3.2.4 Estimation of Blood Urea
Blood urea was estimated by glutamate dehydrogenase (GLDH) and Urease method using ERBA kit (Tiffany et al., 1972). In this procedure 1.0 ml of urea working reagent was taken and 200µl of serum was added and it was considered as test (T). The contents were mixed well and the initial absorbance (A1) was taken at 20 seconds and final absorbance (A2) after 80 seconds at a wavelength of 340 nm. In the Standard(S) 1.0 ml of urea working reagent and 200µl of urea standard were added whereas in Blank (B) 1.0 ml of urea working reagent and 200µl of distilled water was added and the absorbance was calculated by taking the difference between two intervals.
3.2.5 Estimation of Creatinine

Serum creatinine was estimated by alkaline picrate method using ERBA kit (Modified Jaffe’s reaction Bowers, 1980). In this procedure 1.0 ml creatinine working reagent and 100µl of serum was added to the test (T). The contents were mixed well and the initial absorbance (A1) was taken at 20 seconds and final absorbance (A2) after 80 seconds at a wavelength of 505 nm. In the Standard(S) 1.0 ml of creatinine working reagent and 100µl of creatinine standard were added whereas in Blank (B) 1.0 ml of creatinine working reagent and 100µl of distilled water was added and the absorbance was calculated by taking the difference between two intervals.

GFR (eGFR) was computed by employing the following methods:

3.2.6 Estimation of eGFR by Cockcroft-Gault formula (Cockcroft and Gault 1976)

\[
\text{Cockcroft-Gault Creatinine Clearance (ml/min) = } \frac{(140 - \text{age}) \times \text{(weight in kg)}}{\text{Serum Creatinine (mg/dl) x 72}}
\]

(Multiply with 0.85 if female)

CG formula is adjusted to body surface area (BSA) by using DuBois, DuBois method (DuBois and DuBois. 1916) BSA = \(W^{0.425} \times H^{0.725} \times 0.007184\)

Where W= weight and H=height

3.2.7 Estimation of eGFR by MDRD formula (Levey et al., 2000)

\[
\text{MDRD Creatinine Clearance (ml/min/1.73m}^2\) = \frac{186 \times \text{(Serum Creatinine (mg/dl))}^{-1.154} \times \text{(age in years)}^{-0.203}}{0.742}
\]

(Multiply with 0.742 if female)
3.2.8 Estimation of eGFR by MCQE formula (Rule et al., 2004)

The MCQE estimated GFR (ml/min /1.73 m²)

\[ \text{exp} [1.911 + 5.249 / \text{SCr} - 2.114 / \text{SCr}^2 - (0.00686 \times \text{age (years)}] \]

(– 0.205 if female)

Where SCr is Serum Creatinine in mg/dl. Values <0.8 mg/dl set to 0.8 mg/dl, as per the reported method.

3.2.9 Statistical analysis

Data was expressed in Mean and Standard deviation (mean ±SD). Statistical significance between control and cases groups Z test was performed using Microsoft Excel and SPSS software 16.0. The statistical significance was determined at 5% (p < 0.05) level.

3.3 RESULTS AND DISCUSSION

3.3.1 Demographic features and diagnostic parameters

A total of 251 subjects were studied including 123 normal healthy individuals (Control) and 128 diagnosed CKD patients. Mean age of the cases was 46.45±11.78 while that of the controls was 44.02±13.76. As regards the sex distribution, the majority of subjects were male both in control (69%) and CKD patients (62.5%). The most common etiology in CKD patients was diabetes (45%) followed by hypertension (30%), glomerulonephritis (17%) and polycystic kidney disease (8%).

In the present study, blood urea and serum creatinine were significantly raised in CKD patients when compared with control (p<0.001) (Table 3.1) and the rise is due to decreased clearance.

In control group based on BMI 4% are underweight, 60% normal, 24% overweight and 12% are obese. Whereas in cases 12% are underweight, 65% normal, 14% overweight and 8% are obese. Most of the subjects in control and CKD patients had normal BMI. The number of subjects in underweight and obese was much less (Table 3.2).
Table 3.1: Demographic features and diagnostic parameters in Controls and CKD patients

<table>
<thead>
<tr>
<th></th>
<th>Control (n=123)</th>
<th>CKD patients (n=128)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean±SD) years</td>
<td>44.02±13.76</td>
<td>46.45±11.78</td>
</tr>
<tr>
<td>Sex (males %)</td>
<td>69%</td>
<td>62.5%</td>
</tr>
<tr>
<td>(females %)</td>
<td>31%</td>
<td>37.5%</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td></td>
<td>45% (n=58)</td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
<td>30% (n=38)</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td></td>
<td>17% (n=22)</td>
</tr>
<tr>
<td>Polycystic kidney disease</td>
<td></td>
<td>8% (n=10)</td>
</tr>
<tr>
<td>Body weight(kgs)</td>
<td>66.72±6.64</td>
<td>62.70±6.88</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172.67±5.17</td>
<td>172.04±5.93</td>
</tr>
<tr>
<td>Blood urea (mg/dl)</td>
<td>28.55±8.16</td>
<td>99.76±38.13**</td>
</tr>
<tr>
<td>Serum Creatinine (mg/dl)</td>
<td>0.90±0.13</td>
<td>4.49±2.51**</td>
</tr>
</tbody>
</table>

**p<0.001

Legend: The above table shows mean age and sex distribution in control and cases. It also shows common etiology and diagnostic parameters.
Table 3.2: Distribution of Controls and Cases according to BMI

<table>
<thead>
<tr>
<th>BMI</th>
<th>Control (n=123)</th>
<th>Cases (n=128)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under weight (&lt;18.4)</td>
<td>05 (4%)</td>
<td>16 (12%)</td>
</tr>
<tr>
<td>Normal (18.5-22.9)</td>
<td>74 (60%)</td>
<td>83 (65%)</td>
</tr>
<tr>
<td>Over weight (23-24.9)</td>
<td>29 (24%)</td>
<td>19 (14%)</td>
</tr>
<tr>
<td>Obese (&gt;25)</td>
<td>15 (12%)</td>
<td>10 (8%)</td>
</tr>
</tbody>
</table>

Legend: Most of the subjects both control and CKD patients had normal BMI. The number of subjects in both groups in lower and higher spectrum of BMI was much less.

3.3.2 Importance of eGFR

Evaluation of renal function by estimating GFR is one of the most important aspects in the management of CKD. Accurate GFR measurement is carried out by infusion of a substance like 51Cr-EDTA or 99m-Tc-DTP (Nossli et al., 1965). But these are neither cost effective, nor free of risk and hence are not suitable for routine clinical practice. Serum Creatinine is a sensitive marker of GFR associated with changes in renal function (Rosano and Brown 1982). However, serum creatinine alone cannot provide the exact status of the renal impairment because appreciable rise of serum creatinine is required to identify 50% fall in GFR. Therefore, serum creatinine based estimated GFR (eGFR) was introduced for more accurate results, it does not require utilization of nephrotoxic contrast medium, but this procedure requires timed urine collection (24 hours), which introduces its own inaccuracy and inconvenience (Guillausseau et al., 1998)
3.3.3 Cockcroft and Gault formula

In the year 1976, Cockcroft and Gault formulated CG formula on the basis of observations done on male hospitalized patients using 24 hours urine creatinine excretion from two 24 hours urine collections. In case of women, the eGFR is corrected by multiplying with 0.85. The main purpose of CG is to calculate the creatinine clearance (Cockcroft and Gault 1976) but the CG equation is biased because of the body weight parameter in the equation (Rigalleau et al., 2006). Based on body weight CG, overestimates GFR in obese and underestimates in lean individuals. However, this can be overcome by adjusting to body surface area. At the same time, there are doubts about the accuracy of CG formula in individuals with normal renal function especially in older age group people (Poggio et al., 2005) because the age in the CG formula is inversely proportional to eGFR.

3.3.4 MDRD formula

In the year 2000, Levey introduced a new formula which was referred as MDRD and this was based on the renal clearance of $^{125}$I-iothalamate in patients with moderate CKD. But applicability of MDRD in healthy individuals is not clearly understood. The significance of MDRD formula is it does not require patient’s weight and does not need any correction for body surface area. Johnson (2005) and Lamb (2005) reported that it can only estimate lower GFR values that is less than 60 ml/min/1.73m$^2$ with accuracy. Hence it can give better result only when GFR declines. Rule (2004) reported that MDRD did not improve performance even after recalibration of serum creatinine and there is still bias in patients with CKD.

3.3.5 MCQE formula

In the year 2002, NFK-K/DQOI published clinical practice guidelines and proposed uniform use of eGFR for grading CKD and recommended the use of CG and MDRD formulae (Levey et al., 2003), but the accuracy of these two formulae in staging of CKD patients is still debated (National Kidney Foundation, 2002). Corsonelo (2005) suggested that several drugs cause depression of GFR and therefore detection of CKD in early stages where the serum creatinine is near normal and is important for proper therapeutic management. But CG and MDRD formulae have maximum disagreement.
in the low and normal serum creatinine ranges, thus causing inaccuracy (Bostom et al., 2002 and Liu et al., 2003). There exists more controversy around the CG and MDRD accuracy in elderly people (Burkhardt et al., 2005) and End stage renal disease (Kuan et al., 2005). Because of various ambiguities in the assay of eGFR by CG and MDRD methods as highlighted above, the other alternative method i.e., Mayo clinic quadratic equation (MCQE) is taken into consideration for estimating eGFR. In the year 2004, Rule proposed new equation MCQE on the basis of $^{125}$I-iothalamate clearance in 320 patients with CKD and 580 healthy individuals. Due to mixed population, the result of creatinine dependent MCQE gave intermediate performance, though it does not underestimate normal GFR (Rigalleau et al., 2007). Hence MCQE is found to be a better alternative to CG and MDRD (Beauvieux et al., 2007).

### 3.3.6 Comparison of three formulae between control and cases

Estimated GFR (eGFR) values using CG, MDRD and MCQE in CKD patients are significantly lowered when compared with control (p<0.001) (Figure 3.1). This is evident by raised serum creatinine in CKD group. As creatinine is the common parameter in all the three formulae, the CG, MDRD and MCQE based eGFR is altered. In control group, there is no significant difference between CG and MDRD. But MCQE registered significantly higher value of eGFR (p<0.001) when compared with both CG and MDRD. Srinivas et al., 2008 studied GFR by using 99mTc-diethylenetriamine penta acetic acid (DTPA) in renal donors of South Asian population and reported that the mean GFR is 95.5 ml/min/1.73 m$^2$$\pm$11.6. In our study mean GFR by CG, MDRD and MCQE was observed to be 92.12 ml/min/1.73 m$^2$$\pm$20.41, 92.61 ml/min/1.73 m$^2$$\pm$20.52 and 114.94 ml/min/1.73 m$^2$$\pm$19.11 respectively in the control group.
Figure 3.1: eGFR level in Control and cases by using CG, MDRD and MCQE formulae

Legend: When the eGFR values between control and CKD cases were compared on the basis of CG, MDRD and MCQE equation it was observed that the values were significantly decreased (p<0.001) in the CKD cases as per all three equations. In control group, there was no significant variation of GFR with respect to CG and MDRD equation (p= not significant). However the value of clearance as per the MCQE equation was significantly higher (p<0.001) either compared to CG or/and MDRD values. In CKD group, there was no significant difference in eGFR in respect of CG, MDRD and MCQE formulae (p= not significant).

3.3.7 Comparison of three eGFR formulae age wise

In aging process, there is a decline of muscle mass called sarcopenia which leads to decreased level of muscle creatinine and later the serum creatinine levels. But normally there is an increased level of serum creatinine with ageing which is due to a decline in kidney function, typically seen as age advances, and is associated with decreased level of eGFR (Rule et al., 2009 and Douville et al., 2009). In our study of control subjects, it was observed that there was a progressive decline in GFR as the age advances and it is true by all the methods of estimation of GFR (Table 3.3, Figure
3.2). When a comparison was made between CG and MDRD methods in respect of older age group, it was reported by both Garg (Garg et al., 2004) and Wieczorowska (Wieczorowska et al., 2006) that older individuals more than 60 years of age showed a higher value for GFR by the MDRD method in comparison to the CG method. Our observations in the present study with respect to GFR in controls over 60 years of age as estimated by MDRD and CG methods are in agreement with the authors mentioned above. Carnevale et al., 2010 reported that MCQE provides overestimated value in old subjects compared with 24 hours creatinine clearance. In our study of controls, MCQE provided a significantly (p<0.001) higher GFR values in all age groups when compared with CG and MDRD. More or less it is the MCQE method which reasonably approximates to normal GFR values in all age groups.

**Figure 3.2: Calculated eGFR by CG and MDRD and MCQE versus Age**

![Graph showing eGFR by CG, MDRD, and MCQE versus Age](image)

**Legend:** eGFR estimated by using CG, MDRD and MCQE in control subjects, it was observed that there was a progressive decline of GFR as age advances. In all the age groups in controls the eGFR as per MCQE method was significantly higher when compared with CG and MDRD.
### Table 3.3: Age wise eGFR in Controls by using CG, MDRD and MCQE

<table>
<thead>
<tr>
<th>Age</th>
<th>CG (ml/min/1.73m²)</th>
<th>MDRD (ml/min/1.73m²)</th>
<th>MCQE (ml/min/1.73m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29 (n=24)</td>
<td>113.89±19.75</td>
<td>108.46±22.24</td>
<td>133.56±15.14**</td>
</tr>
<tr>
<td>30-39 (n=24)</td>
<td>103.44±16.02</td>
<td>99.50±20.02</td>
<td>124.27±16.67**</td>
</tr>
<tr>
<td>40-49 (n=28)</td>
<td>89.36±13.47</td>
<td>87.22±18.07</td>
<td>110.23±15.84**</td>
</tr>
<tr>
<td>50-59 (n=30)</td>
<td>79.08±10.96</td>
<td>84.75±16.16</td>
<td>105.58±14.30**</td>
</tr>
<tr>
<td>60-70 (n=17)</td>
<td>72.93±9.74</td>
<td>83.28±13.84*</td>
<td>99.77±12.79**</td>
</tr>
</tbody>
</table>

* *p*<0.05; ** *p*<0.001

**Legend:** eGFR when compared age wise in control group, it was noticed that there was no significant difference in the 20-29, 30-39, 40-49 and 50-59 years range with respect to CG and MDRD equation (*p*=not significant). But in the age range of 60-70 years, the eGFR is significantly higher (*p*< 0.05) as per the MDRD equation.

In all the age groups in controls the GFR as per MCQE method was significantly higher when compared with CG and MDRD (*p*<0.001)

### 3.3.8 Distribution of controls in to different stages on the basis of eGFR

In our study both CG and MDRD formulae included normal healthy individuals in stage 2 and stage 3 of CKD though there was no apparent evidence of renal impairment and they had a normal serum creatinine level. They comprised 46.4% in stage 2 by CG and 48% by MDRD. In case of stage-3 the inclusion of healthy individuals was to the extent of 1.6% by both the CG and MDRD equations (Table 3.4). This suggests that CG and MDRD underestimate GFR. In case of MDRD, it generally underestimates GFR at the higher end or within normal ranges and provides inaccurate results (Ibrahim *et al.*, 2005). Both the MDRD and CG prediction formulae perform poorly in patients with normal or near-normal renal...
function (Lin et al., 2003). The new equation MCQE placed only 10% of healthy individuals in CKD stage 2 and there was not a single case of control in stage 3.

Both the CG and MDRD formulae included around 50% of control population under CKD category with a GFR less than <90 ml/min/1.73m². Although Barai et al., (2005) put forth that normal healthy Indian population has a lesser GFR compared to Western population, a more recent study by Rajeshwari et al., (2011) in Indians has reported that CG and MDRD equation classified more than 50% subjects in stage 2 of CKD and 0.8 to 1.4 % under stage 3 of CKD depending on equation. Therefore the observation in our study in healthy control population is in concurrence with the findings of Rajeshwari (2011).

Table 3.4: Distribution of controls in to different stages on the basis of eGFR

<table>
<thead>
<tr>
<th>Stages</th>
<th>CG (ml/min/1.73m²)</th>
<th>MDRD (ml/min/1.73m²)</th>
<th>MCQE (ml/min/1.73m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-59 ml/min/1.73m²</td>
<td>02 (1.6%)</td>
<td>02 (1.6%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>60-89 ml/min/1.73m²</td>
<td>57 (46.4%)</td>
<td>59 (48%)</td>
<td>12 (10%)</td>
</tr>
<tr>
<td>&gt;90-120 ml/min/1.73m²</td>
<td>64 (52%)</td>
<td>62 (50.4%)</td>
<td>111(90%)</td>
</tr>
</tbody>
</table>

Legend: In control group both CG and MDRD equation included a much higher number of normal individuals are having eGFR value below <90 mL/min/1.73m² this constitute 47.9% 47.5% with respect to CG and MDRD thus many control cases which apparently normal are included as CKD patients with stage 2 and stage 3. As per MCQE method only 10% of control cases belong to stage 2 of CKD. Therefore MCQE is a comparatively better method for assessing GFR in healthy control individual.
3.3.9 Distribution of cases into different stages on the basis of eGFR

In CKD patients serum creatinine is raised due to an alteration in renal function and is finally reflected in decreased GFR. In clinical practice, staging of CKD is very important because it is essential for management and medication. Generally stage 1 and 2 are asymptomatic, anemia is a common feature in stage 3 to 5 and in stage 5 serious features like neuropathy and pericarditis, dialysis becomes mandatory. The three formulae CG, MDRD and MCQE which are employed to estimate GFR and stage the CKD patients have their own advantages and disadvantages in classifying CKD. There may not be a single equation available for accurate measurement of eGFR in both controls and renal impairment groups (Dharmarajan et al., 2012).

Table 3.5: Stage wise classification of CKD patients by using CG, MDRD and MCQE

<table>
<thead>
<tr>
<th>Stages</th>
<th>CG (ml/min/1.73m²)</th>
<th>MDRD (ml/min/1.73m²)</th>
<th>MCQE (ml/min/1.73m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1&gt;90</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>60-89 ml/min/1.73m²</td>
<td>01 (0.7%)</td>
<td>01 (0.7%)</td>
<td>03 (2%)</td>
</tr>
<tr>
<td>Stage 3 30-59 ml/min/1.73m²</td>
<td>36 (28%)</td>
<td>33 (26%)</td>
<td>30 (23%)</td>
</tr>
<tr>
<td>Stage 4 15-29 ml/min/1.73m²</td>
<td>41 (32%)</td>
<td>36 (28%)</td>
<td>34 (27%)</td>
</tr>
<tr>
<td>Stage 5&lt;15</td>
<td>50 (39%)</td>
<td>58 (45.3%)</td>
<td>61 (48%)</td>
</tr>
</tbody>
</table>

Legend: The distribution of CKD cases into different stages on the basis CG, MDRD and MCQE do not have any appreciable difference therefore, for the assessment of renal function in CKD patients, any of the above three methods can serve their usual purpose.

In our study in CKD groups (Table 3.5) the three formulae did not include any subject under stage 1. This could be due to the reason that the subjects might not have sought any medical assistance as they did not manifest any clinical features of CKD with a normal or near normal GFR. In stage 2, CG, MDRD and MCQE included only 0.8%, 0.8% and 2% of CKD cases respectively. As the features of the diseases are not very severe to demand attention, the patients in this category do not usually visit a hospital nor seek medical attention accounting for their lack of awareness. The other reason
for only a few number of subjects falling under stage 1 and stage 2 in CKD may be due to that, the three formulae underestimated GFR as they might have also done in controls. Therefore staging becomes inappropriate.

Most of the patients of CKD in our study belonged to Stages 3 to 5 with a higher preponderance in stage 5 as the data obtained were from the dialysis unit of the hospital. With respect to stages 3 and 4, there is no significant difference in the distribution of CKD cases with reference to all the equations. Stage 3 comprises of 28.2%, 26% and 23% of CKD cases according to CG, MDRD and MCQE respectively. Likewise stage 4 includes 32%, 28.2% and 27% of total CKD patients according to CG, MDRD and MCQE respectively. Therefore it can be inferred that with regard to stages 3 and 4 of CKD, the difference according to the three methods employed to assess GFR is not significant. The distribution of CKD cases in stage 5 is almost similar according to MDRD and MCQE methods and comprise 45.3% and 48% respectively. It is the CG equation which gives a lower value of 39%. Thus there exists an incompatibility in grading patients in stage 5. Therefore taking into account the whole gamut of CKD patients, it can only be stated with some reservation that either MDRD or MCQE equation can be used to assess GFR as both of them have close resemblance. Thus our observations in CKD cases are in concurrence with the observations of Marsik et al., (2008).

3.4 CONCLUSION

In view of various conflicting and ambiguous reports in the literature regarding the assessment and acceptability of GFR values in CKD patients it has become practically a very intricate and complicated predicament on the part of medical professionals to categorize the patients into different stages and institute appropriate treatment. However the present study infers with some degree of reservation that MCQE formula is acceptable for normal controls, MDRD and MCQE are both satisfactory for CKD patients.