Incidence and risk of dialysis therapy within 30 days after contrast enhanced computed tomography in patients coded with chronic kidney disease: A nation-wide, population-based study

Yun-Ju Shih [1] , **Yu-Ting Kuo** [1, 2, 3] , **Chung-Han Ho** [4, 5] , **Chia-Chun Wu** [6, 7] , **Ching-Chung Ko** [Corresp. 1, 8]

[1] Department of Medical Imaging, Chi Mei Medical Center, Tainan, Taiwan

[2] Department of Medical Imaging, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan

[3] Department of Radiology, Faculty of Medicine, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan

[4] Department of Medical Research, Chi Mei Medical Center, Tainan, Taiwan

[5] Department of Hospital and Health Care Administration, Chia Nan University of Pharmacy and Science, Tainan, Taiwan

[6] Division of Nephrology, Department of Internal Medicine, Chi Mei Medical Center, Tainan, Taiwan

[7] Department of Pharmacy, Chia Nan University of Pharmacy and Science, Tainan, Taiwan

[8] Center of General Education, Chia Nan University of Pharmacy and Science, Tainan, Taiwan

Corresponding Author: Ching-Chung Ko
Email address: crazyboy0729@gmail.com

Background. Patients with chronic kidney disease (CKD) are considered at risk of contrast-induced acute kidney injury and possible subsequent need for dialysis therapy. Computed tomography (CT) is the most commonly performed examination requiring intravenous iodinated contrast media (ICM) injection. The actual risk of dialysis in CKD patients undergoing CT with ICM remains controversial. Furthermore, it is also uncertain whether these at-risk patients can be identified by means of administrative data. Our study is conducted in order to determine the incidence and risk of dialysis within 30 days after undergoing contrast enhanced CT in CKD coded patients.

Methods. This longitudinal, nation-wide, populated-based study is carried out by analyzing the Taiwan National Health Insurance Research Database (NHIRD) retrospectively. Patients coded under the diagnosis of CKD who underwent CT are identified within randomly selected one million subjects of the database. From January 2012 to December 2013, four hundred and eighty-seven patients had undergone CT with ICM. Nine hundred and twenty-four patients who underwent CT without ICM are selected as the control group. Patients with advanced CKD or intensive care unit (ICU) admissions are assigned to the subgroups for analysis. The primary outcome is measured by dialysis events within 30 days after undergoing CT scans. The cumulative incidence is assessed by the Kaplan-Meier method and log-rank test. The risk of 30-day dialysis relative to the control group is analyzed by the Cox proportional hazards model after adjusting for age, sex and baseline comorbidities.

Results. The numbers and percentages of dialysis events within 30 days after undergoing CT scans are 20 (4.1%) in the CT with ICM group and 66 (7.1%) in the CT without ICM group (p=0.03). However, the adjusted hazard ratio (aHR) for 30-day dialysis was 0.84 (95% CI: 0.46-1.54, p=0.57), which is statistically non-significant. In both advanced CKD and ICU admission subgroups, there are also no significant differences in 30-day dialysis risks with the aHR of 1.12 (95% CI: 0.38-3.33, p=0.83) and 0.95 (95% CI: 0.44-2.05, p=0.90), respectively.

Conclusions. Within 30 days of receiving contrast-enhanced CT scans, 4.1% of CKD coded patients required dialysis, which appear to be lower compared with subjects who received non-contrast CT scans. However, no statistically significant difference is observed after adjustments are made for other baseline conditions. Thereby, the application of administrative data to identify patients with CKD cannot be viewed as a risk factor for the necessity to undergo dialysis within 30 days of receiving contrast-enhanced CT scans.

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Yun-Ju Shih[1], Yu-Ting Kuo[123], Chung-Han Ho[45], Chia-Chun Wu[67], Ching-Chung Ko[18]

Department of Medical Imaging, Chi Mei Medical Center, Tainan, Taiwan[1]
Department of Medical Imaging, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan[2]
Department of Radiology, Faculty of Medicine, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan[3]
Department of Medical Research, Chi Mei Medical Center, Tainan, Taiwan[4]
Department of Hospital and Health Care Administration, Chia Nan University of Pharmacy and Science, Tainan, Taiwan[5]
Division of Nephrology, Department of Internal Medicine, Chi Mei Medical Center, Tainan, Taiwan[6]
Department of Pharmacy, Chia Nan University of Pharmacy and Science, Tainan, Taiwan[7]
Center of General Education, Chia Nan University of Pharmacy and Science, Tainan, Taiwan[8]

Corresponding Author:
Ching-Chung Ko[18]
Postal address: No.901, Zhonghua Rd. Yongkang Dist., Tainan City 71004 Taiwan
Email address: crazyboy0729@gmail.com

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Abstract

Background. Patients with chronic kidney disease (CKD) are considered at risk of contrast-induced acute kidney injury and possible subsequent need for dialysis therapy. Computed tomography (CT) is the most commonly performed examination requiring intravenous iodinated contrast media (ICM) injection. The actual risk of dialysis in CKD patients undergoing CT with ICM remains controversial. Furthermore, it is also uncertain whether these at-risk patients can be identified by means of administrative data. Our study is conducted in order to determine the incidence and risk of dialysis within 30 days after undergoing contrast enhanced CT in CKD coded patients.

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Conclusions. Within 30 days of receiving contrast-enhanced CT scans, 4.1% of CKD coded patients required dialysis, which appear to be lower compared with subjects who received non-contrast CT scans. However, no statistically significant difference is observed after adjustments are made for other baseline conditions. Thereby, the application of administrative data to identify patients with CKD cannot be viewed as a risk factor for the necessity to undergo dialysis within 30 days of receiving contrast-enhanced CT scans.

Introduction

Administration of intravenous iodinated contrast media (ICM) during computed tomography (CT) scans plays an indispensable role in improving diagnostic performance in numerous settings and is thereby widely employed in clinical practice. The healthcare industry has seen a steady increase in demand for CT scans ordered by clinicians, which inevitably leads to a corresponding increase in use of ICM. (Hu et al. 2016) However, intravenous ICM also raises major concerns of the development of contrast-induced acute kidney injury (CI-AKI). The

79 exact pathophysiology leading to this condition is poorly understood, but could possibly result
80 from contrast-induced vasoconstriction, a decrease in filtration via tubuloglomerular feedback,
81 direct renal epithelial toxicity and increased free radial formation. (Pasternak & Williamson 2012)
82 The elevations of blood osmolality and tubular fluid viscosity may also cause microvascular
83 thrombosis and renal tubular obstruction, respectively. (Mehran et al. 2019) After excluding
84 other etiologies of renal impairment, the diagnostic criteria for CI-AKI are serum creatinine
85 elevation varying from 0.3 to 0.5 mg/dL in an absolute increase, or a 25 to 50% relative increase
86 within the time period of 24 to 72 hours after contrast administration. (McDonald et al. 2013;
87 Mehran & Nikolsky 2006; Meinel et al. 2014)

88   It is known that patients with chronic kidney disease (CKD) are particularity at risk of
89 developing CI-AKI due to diminished renal function reserve. (Davenport et al. 2013; Kim et al.
90 2010; ACR committee on drugs and contrast media 2018; Mehran & Nikolsky 2006;
91 Scharnweber et al. 2017) However, there is also emerging evidence suggesting that the risk of
92 CI-AKI in CKD patients may have been overestimated in the past. (Garfinkle et al. 2015; Hinson
93 et al. 2017; McDonald et al. 2013; Mehran et al. 2019; van der Molen et al. 2018) The type,
94 amount and route of ICM given to a patient are also crucial parameters. Patients receiving high-
95 osmolar contrast medium (HOCM), i.e. ionic monomers, large volumes of ICM administration,
96 or intraarterial ICM injections are at high risks of developing CI-AKI, (Pasternak & Williamson
97 2012) and these findings are mostly based on studies focusing on coronary interventional
98 procedures. However, the doses given during contrast-enhanced CT scans are intravenous and
99 usually smaller in volumes as compared with coronary interventional procedures. In addition, the
100 majority of ICM now used in modern clinical practices are low-osmolar (LOCM) and iso-
101 osmolar contrast media (IOCM). Therefore, many are now questioning the existence of clinically
102 significant CI-AKI in this setting. (Mehran et al. 2019; Pasternak & Williamson 2012) Baselines
103 fluctuations in renal function indices may also cause spurious indications of CI-AKI, which are
104 unrelated to ICM administration. (Bruce et al. 2009) Nevertheless, it is the current consensus
105 amongst practicing radiologists that pre-existing CKD is still the most important risk factor in the
106 development of CI-AKI. (ACR committee on drugs and contrast media 2018; van der Molen et
107 al. 2018) In addition, the prevalence of CKD is high in many countries. (Hill et al. 2016) If the
108 risk is truly overestimated, contrast-enhanced CT scans may be inappropriately withheld from
109 patients with legitimate clinical indications, resulting in suboptimal or delayed diagnoses of
110 serious conditions and unfavorable clinical outcomes.

111   CI-AKI is often but not always a reversible process. (Scharnweber et al. 2017) One of the
112 adverse events after CI-AKI causing the greatest concern is the possible necessity for dialysis
113 therapy due to sustained renal function impairment. The exact figure for CKD patients who
114 require dialysis shortly after undergoing CT with ICM is not well known, and it possess a high
115 level of clinical interest. The necessity for dialysis in the short-term is defined within a time-
116 frame of 30 days after undergoing CT scan, in concordance with other studies published in the
117 literature. (McDonald et al. 2015; McDonald et al. 2017a; McDonald et al. 2014) To directly
118 identify CKD patients, it is essential to obtain laboratory information. An alternative method is to

119   select patients with CKD based on diagnostic codes within an administrative dataset. The
120   usefulness for administrative data regarding CKD status has been validated in various research
121   articles, which reveal inconsistent sensitivities but very high specificities. (Grams et al. 2011;
122   Navaneethan et al. 2011; Ronksley et al. 2012; Tonelli et al. 2015) In the published literature,
123   numerous studies have been conducted implementing diagnostic codes to identify CKD patients.
124   (Chang et al. 2014; Chen et al. 2016; Chung et al. 2017; Sebastian Yu 2017) In this study, a
125   longitudinal, nation-wide, population-based data is used to evaluate the incidence and risk of the
126   necessity for dialysis within 30 days of undergoing contrast-enhancing CT scans amongst CKD
127   patients. It is also our imperative to determine whether the administrative data is able to
128   successfully identify CKD patients who are at risk.
129
130   **Materials & Methods**
131   **Study design and setting.** The National Health Insurance (NHI) program in Taiwan,
132   launched in March of 1995, is a compulsory single-payer social insurance plan aimed at
133   delivering healthcare to all citizens. It covers nearly all of the twenty-three million people living
134   in Taiwan. The National Health Insurance Registry Database (NHIRD) is a database containing
135   comprehensive information such as demographic data, diagnostic codes, drug prescription and
136   procedure codes after encryption of patients' personal information. For research purposes, a
137   subset of database, namely, the Longitudinal Health Insurance Database 2010 (LHID2010), was
138   provided by the National Health Research Institutes, and it had been implemented in numerous
139   research articles. (Chang et al. 2015; Chou et al. 2015; Ho et al. 2014; Wu et al. 2014) This
140   dataset contains of one million individuals chosen randomly from the NHIRD at the year 2010
141   and contains medical information from January 1997 to December 2013 of each subject under
142   the coverage. The Catastrophic Illness Registry Data file was supplemented for identification of
143   deaths during the study period. The Institutional Review Board in the Chi Mei Medical Center
144   passed approval of this study (No: 10706-E03) and requirement of informed consent was waived.
145   **Patient identification and selection.** Within the LHID2010, CKD patients were identified
146   by using relevant *International Classification of Diseases, Ninth Revision, Clinical Modification*
147   (ICD-9-CM) codes with at least two outpatient claims or one inpatient claim documented in the
148   diagnosis codes section. Patients receiving CT scans were selected by using the Taiwan NHI
149   codes for procedures, including information on study date and the presence or absence of ICM
150   administration. The specific ICM injected was unknown, however the majority of ICM used in
151   Taiwan is LOCM, i.e. non-ionic monomers. CKD patients receiving CT without ICM were
152   assigned to the control group. The specific dates of CT scans were not available before year 2012
153   within LHID2010, therefore only CKD patients receiving CT during January 2012 to December
154   2013 were included for analysis. The following patients were excluded: ages below 20 or over
155   100 years old; patients who were already receiving regular dialysis before the date of the CT
156   scan; patients receiving CT scans for 2 or more times within 30 days; and patients who had
157   undergone angiography or transarterial embolization within 30 days of the CT scan. The flow
158   diagram for patient selection was shown in *Fig. 1*. All included patients were followed up for a

159   30-day period, to the occurrence of dialysis or death events, until the end of December 2013 or
160   when leaving the NHI program. The follow-up period was not limited to 30 days when
161   evaluating the time interval from CT to dialysis event as a secondary outcome described
162   subsequently. Furthermore, since laboratory data was not available in LHID2010, the severity of
163   CKD could not be directly assessed. An indirect approach was to select CKD patients receiving
164   erythropoietin-stimulating agents (ESA) as the advanced CKD subgroup in this study. The NHI
165   reimbursed ESA only in CKD patients with serum creatinine above 6 mg/dL, approximately
166   equivalent to an estimated glomerular filtration rate (eGFR) <15 mL/min/1.73m^2, and a
167   hematocrit level below 28% observed concurrently. This approach to subdivide patients with
168   advanced CKD had also been used in previous research articles. (Chung et al. 2017; Hsieh et al.
169   2016) Another subgroup was the status of admission to the intensive care unit (ICU) during the
170   time the CT scan was performed.
171   **Assessment of comorbidities and confounding factors.** Data including age, sex and
172   comorbid conditions were collected and incorporated into the statistical analyses. The age was
173   stratified into < 60 years old, 60 - 80 years old and > 80 years old groups. Baseline hypertension,
174   diabetes mellitus, ischemic heart disease, peripheral arterial occlusive disease, congestive heart
175   failure, liver cirrhosis, hyperlipidemia and anemia were recorded based on the ICD-9-CM codes
176   before the date of the CT scan was performed.
177   **Outcomes measurement**. The primary outcome was measured by the occurrence of
178   dialysis events within 30 days of CT scans, which was recognized by Taiwan NHI codes for
179   procedures. The secondary outcomes were dialyses within 30 days of CT scans in the two
180   selected subgroups, dialysis in CKD excluding ICU patients, death within 30 days, and the time
181   interval of dialysis therapies after CT scans in the advanced CKD subgroup.
182   **ICD-9-CM codes and Taiwan NHI codes for procedures**. CKD patients were identified
183   by using the ICD-9-CM codes and include the followings: 585 (chronic kidney disease), 582
184   (chronic glomerulonephritis), 403 (hypertensive chronic kidney disease) and 404 (hypertensive
185   heart and chronic kidney disease). Baseline comorbidities were also recognized with ICD-9-CM
186   codes as the followings: hypertension (401-405), diabetes mellitus (250, 357.2, 362.01, 362.02,
187   and 366.41), ischemic heart disease (411-414), peripheral arterial occlusive disease (440-444),
188   congestive heart failure (428), liver cirrhosis (571.2, 571.5, and 571.6), hyperlipidemia (272-
189   272.4) and anemia (280-285). CT with ICM studies were searched by Taiwan NHI codes for
190   procedures, both 33071B (CT with contrast) and 33072B (CT without and with contrast); CT
191   without ICM studies were identified by Taiwan NHI codes for procedures 33070B (CT without
192   contrast). Dialysis events were selected by using Taiwan NHI codes for procedures
193   58001C/58029C/58027C (hemodialysis) and 58018C (continuous veno-venous hemofiltration
194   dialysis).
195   **Statistical analysis**. Patient characteristics between the CT with ICM and CT without ICM
196   groups, including age, sex and comorbid conditions, were compared by using the Pearson's chi-
197   square test for categorical variables. Kaplan–Meier analysis was performed to assess the
198   cumulative incidence of dialysis between these two groups, and the log-rank test was used to

199   measure the difference of incidence curves. The Cox proportional hazard model adjusted for age,
200   sex and comorbid conditions was used to demonstrate the risk ratio of dialysis and death between
201   the two groups. Each of the baseline characteristic was viewed as a distinct dichotomous variable.
202   Adjusted hazard ratios (aHR) and 95% confidence intervals (95% CI) were calculated. The result
203   for the time interval leading up to dialysis in advanced CKD subgroup was not following the
204   Gaussian distribution; therefore, the median value, the first quartile, and the third quartile were
205   reported. All statistical analyses were performed using Statistical Analysis System (SAS)
206   statistical software (version 9.4; SAS Institute Inc., Cary, NC, USA). The Kaplan-Meier curves
207   were plotted using STATA (version 12; Stata Corp., College Station, TX, USA). A two-tailed p-
208   value of < 0.05 was considered statistically significant.
209
Results
210
211   **Baseline characteristics of the study participants.** There were 1411 eligible CKD patients
212   who underwent CT studies, including 487 patients receiving CT with ICM and 924 patients
213   receiving CT without ICM. Patient characteristics are listed in *Table 1*. In the CT with ICM
214   group, patients were younger, more of them were male, and a greater number of subjects had
215   liver cirrhosis. On the other hand, there were more patients with hypertension, diabetes mellitus,
216   hyperlipidemia and anemia in the CT without ICM group. We identified 99 patients with
217   advanced CKD who were undergoing ESA therapy: 15 of them received CT with ICM and 84
218   patients received CT without ICM. There were also 227 patients (16.1%) staying in the ICU, and
219   a greater number of these subjects underwent CT without ICM.
220   **Necessity for dialysis and death within 30 days of CT.** There were 20 patients (4.11%) in
221   the CT with ICM group and 66 patients (7.14%) in the CT without ICM group requiring dialysis
222   within 30 days of CT scans. The cumulative incidences of dialysis events were drawn in *Fig. 2*.
223   A greater number of patients underwent dialysis therapy in the CT without ICM group
224   (p=0.0295). However, no statistically significant difference was found after the adjustment of
225   age, sex and the specified comorbid conditions (aHR 0.84, 95% CI 0.46-1.54, p=0.5700). Sixteen
226   patients (3.29%) died in the CT with ICM group, which was also not significantly different from
227   the 61 patients (6.60%) who died in the CT without ICM group (aHR 0.62, 95% CI 0.35-1.10,
228   p=0.1012). In the advanced CKD and ICU admission subgroups, neither dialysis within 30 days
229   after CT nor death rates differ significantly between the CT with or without ICM groups. After
230   excluding the critically-ill patients in the ICU, the percentages of patients requiring dialysis in 30
231   days was 1.61% in the CT with ICM and 2.81% in the CT without ICM groups, respectively
232   (aHR 1.11, 95% CI 0.40-3.06, p=0.8371). The events, percentages and adjusted hazard ratios of
233   dialysis and death are shown in *Table 2*.
234   **Time to dialysis in advanced CKD subgroup.** The time interval leading up to dialysis in
235   the advanced CKD subgroup is demonstrated in *Table 3*. A total of 75 patients (75.8%) required
236   dialysis after CT. The median time interval leading to dialysis was 12 days (Q1-Q3: 4-139) in the
237   CT with ICM group and 38 days (Q1-Q3: 4-184.5) in the CT without ICM group.
238

Discussion

239

240   In our study, the adjusted risks of dialysis and death within 30 days after CT scans in CKD
241 patients were not increased, regardless of whether the patient received ICM or not. Similar
242 results were reported in three retrospective studies from the same institution. (McDonald et al.
243 2015; McDonald et al. 2017a; McDonald et al. 2014) Regardless of CKD stage 3, 4 or 5, the
244 incidences of dialysis and death rates were also not affected by ICM. (Garfinkle et al. 2015;
245 McDonald et al. 2015; McDonald et al. 2017a) Therefore, CT with ICM is probably not an
246 independent risk factor for the necessity of dialysis and event of death in CKD patients, even in
247 advanced stages, in the short-term observation. The crude dialysis rate was lower in our CT with
248 ICM group, although not statistically significant after adjustment. One reason could be the
249 younger age and the existence of fewer comorbid conditions in this group. The crude dialysis
250 rate elevation in CKD patients receiving CT without ICM was observed by others as well.
251 (McDonald et al. 2017a) A recent meta-analysis consisted of patients with acute ischemic stroke
252 also revealed a lower CI-AKI risk in those receiving contrast enhanced CTs as compared with
253 those who received non-enhanced ones. (Brinjikji et al. 2017) Consistent with our results, they
254 became non-significant after the adjustment of confounding factors. It is possible that various
255 predisposing conditions lead to concerns of developing CI-AKI, and clinicians may have ordered
256 non-contrast CTs instead. The underlying causes may have resulted in renal failure and
257 subsequent elevation in the crude dialysis rate in our studied population.

258   Reported post-CT dialyses within 30 days were few in the reviewed studies, with an overall
259 percentage of 0.2 to 0.3% in CKD patients and only 5.1% in CKD stages 4-5 patients.
260 (McDonald et al. 2017a; McDonald et al. 2014) However, our study revealed higher rates of
261 post-CT dialyses within 30 days at 4.1 to 7.1%. When excluding the critically-ill ICU patients,
262 the percentages were still high at 1.6 to 2.8%. This finding could be related to the fact that
263 Taiwan has the highest incidence of end-stage renal disease (ESRD) in the world. (United States
264 Renal Data System, 2017) Abundant dialysis-related resources are available, and the NHI
265 provides full coverage of incurred expenses. Due to this relatively common practice, doctors,
266 patients and their family members would probably prefer dialysis therapy in the occurrence of
267 renal failure in most situations. Another possible cause is that some CKD patients were
268 unlabeled from ICD-9-CM, especially those with less severe disease. (Ferris et al. 2009)
269 Therefore, the reported incidences of dialyses could be overestimated in our study.

270   The importance of critical illness was mentioned in a previous study, stating that ICU
271 patients with eGFR < 45 mL/min/1.73m^2 demonstrated an increased risk of emergent dialysis
272 within 7 days after contrast enhanced CT scans. (McDonald et al. 2017b) An earlier article also
273 demonstrated that the development of CI-AKI may result in increased need for dialysis in the
274 ICU (Valette et al. 2012). However, in our results, the necessity for post-CT dialysis within 30
275 days and death rates did not differ in the ICU subgroup. A more detailed stratification of patient
276 condition, especially any acute illness, might be required to reveal any undesirable effect of ICM
277 injected during CT particularly in the critically-ill setting.

278   The advanced CKD subgroup appears interesting since they were presumed to be most

279 susceptible to CI-AKI and the possibility of dialysis. It is noteworthy that one previous study
280 mentioned that CKD patients who underwent exposure to ICM during CT scans more than once
281 per year may develop ESRD earlier in the time scale of years. (Hsieh et al. 2016) However, CKD
282 patients with concurrent usage of ESA were excluded from their study due to proposed short-
283 interval deterioration of residual renal function. Therefore, these pre-dialysis patients are the
284 focus of our scrutiny in determining whether the time-interval to dialysis requirement after
285 intravenous ICM exposure shortens. The result, however, included only small numbers of
286 patients as the median time decreased from 38 to 12 days. It was inconclusive while containing
287 wide interquartile ranges. Further investigation is warranted to clarify whether contrast exposure
288 truly shortened the time to dialysis requirement in advanced CKD patients.
289   This is the first national database study to describe CKD patients receiving CT with ICM is
290 not associated with higher risk of dialysis in the short-term. The advantage of this study is the
291 conduction of a nation-wide population-based design to minimize potential single institution
292 related biases. Whether the risk of CI-AKI varies among different races remains unclear,
293 (Chawla et al. 2017; Powell et al. 2018) yet there are no previous papers articles aimed
294 specifically at Asians before this current study. In addition, it is unknown if CKD patients
295 identified from administrative data can be viewed as a risk factor in terms of dialysis requirement
296 within 30 days before our present study.
297   Considering that the information was extracted from a national research database, the
298 cohort size appeared smaller than expected; but it was also a result of our rigorous selection
299 criteria. Even if, our results offered valuable information in clinical practice. Although the
300 relatively small cohort size may decrease the statistical power and increase the risk of a false
301 negative result, our case numbers of dialysis events to be analyzed were larger than previous
302 comparable studies showing the same results. (McDonald et al. 2015; McDonald et al. 2014)
303   This study still has several other limitations. The recognition of diagnoses including CKD
304 and comorbid conditions were based on ICD-9-CM diagnostic codes, and cases of mis-
305 registration cannot be excluded. The indications for CT scans were unknown, and acute medical
306 illnesses were also not analyzed due to database restrictions. Details on the volume and specific
307 ICM injected were not retrievable in our dataset, but the majority of ICM used were LOCM
308 among routine clinical practice in Taiwan. HOCM has now become obsolete, and IOCM is rarely
309 used. There is no sufficient evidence to suggest a significant CI-AKI risk difference between
310 LOCM and IOCM, (Eng et al. 2016) and our results will unlikely change when considering that
311 few patients actually received IOCM. And lastly, this is a retrospective cohort study, which
312 inevitably contains biases inherently related to the study design. For further investigation, a well-
313 designed prospective cohort study in CKD patients comparing those receiving CT with or
314 without ICM can be conducted. The type and volume of ICM, acute medical conditions,
315 nephrotoxic medications and preventive measurements should be controlled. Novel biomarkers
316 to predict CI-AKI and dialysis therapy requirement could also be studied in the future.
317
318 **Conclusions**

319   In our population-based study, the percentage of CKD patients who require dialysis within
320   30 days of undergoing contrast enhanced CT scans is 4.1%, a lower incidence compared with
321   subjects who receive non-contrast enhanced scans. However, no statistically significant
322   difference is observed after adjustments are made for other baseline conditions. Patients with
323   CKD identified via the application of administrative data, therefore, do not appear to be at risk of
324   dialysis within 30 days after CT with ICM studies.
325

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463

Baseline characteristics of the studied CKD patients

* p<0.05 and are considered statistically significant by Pearson's chi-square test

ICM, iodinated contrast media; HTN, hypertension; DM, diabetes mellitus; PAOD, peripheral arterial occlusive disease; CHF, congestive heart failure; ESA, erythropoietin-stimulating agents; ICU, intensive care unit

1 Table 1:

2 Baseline characteristics of the studied CKD patients

	CT with ICM N=487 (%)	CT without ICM N=924 (%)	p-value
Age group, years			
<60	146 (29.98)	171 (18.51)	<0.0001*
60-80	238 (48.87)	466 (50.43)	
≧80	103 (21.15)	287 (31.06)	
Sex			
Female	197 (40.45)	432 (46.75)	0.0236*
Male	290 (59.55)	492 (53.25)	
Comorbidities			
HTN	401 (82.34)	824 (89.18)	0.0003*
DM	267 (54.83)	582 (62.99)	0.0029*
IHD	263 (54.00)	528 (57.14)	0.2587
PAOD	108 (22.18)	221 (23.92)	0.4621
CHF	113 (23.20)	238 (25.76)	0.2913
Cirrhosis	53 (10.88)	47 (5.09)	<0.0001*
Hyperlipidemia	273 (56.06)	568 (61.47)	0.0488*
ESA usage (advanced CKD)			
Yes	15 (3.08)	84 (9.09)	<0.0001*
ICU admission			
Yes	51 (10.47)	176 (19.05)	<0.0001*

5 * $p < 0.05$ and are considered statistically significant by Pearson's chi-square test

6 ICM, iodinated contrast media; HTN, hypertension; DM, diabetes mellitus; PAOD, peripheral

7 arterial occlusive disease; CHF, congestive heart failure; ESA, erythropoietin-stimulating agents;

8 ICU, intensive care unit

Adjusted hazard ratios (HR) for dialysis and death within 30 days after contrast enhanced CT scans in CKD patients, advanced CKD subgroup, ICU admission subgroup and CKD patients excluding ICU admissions

n/N, event numbers/total numbers

ICM, iodinated contrast media; ICU, intensive care unit

^ Advanced CKD subgroup is defined as CKD patients with concurrent usage of erythropoietin-stimulating agents.

* The HRs were adjusted by the age, sex and comorbidities listed in Table 1.

1   Table 2:

2   Adjusted hazard ratios (HR) for dialysis and death within 30 days after contrast enhanced CT

3   scans in CKD patients, advanced CKD subgroup, ICU admission subgroup and CKD patients

4   excluding ICU admissions

	Outcome	CT with ICM N=487 n/N (%)	CT without ICM N=924 n/N (%)	Adjusted HR* (95% CI)	p-value
CKD patients	30-day dialysis	20 (4.11)	66 (7.14)	0.84 (0.46-1.54)	0.5700
	30-day mortality	16 (3.29)	61 (6.60)	0.62 (0.35-1.10)	0.1012
Advanced CKD subgroup	30-day dialysis	7 (46.67)	30 (35.71)	1.12 (0.38-3.33)	0.8333
	30-day mortality	2 (13.33)	4 (4.76)	3.87 (0.16-92.07)	0.4032
ICU admission subgroup	30-day dialysis	13 (25.49)	45 (25.57)	0.95 (0.44-2.05)	0.8973
	30-day mortality	6 (11.76)	42 (23.86)	0.84 (0.22-1.33)	0.1788
CKD patients excluding ICU admission	30-day dialysis	7 (1.61)	21 (2.81)	1.11 (0.40-3.06)	0.8371
	30-day mortality	10 (2.29)	19 (2.54)	1.24 (0.54-2.85)	0.6158

7   n/N, event numbers/total numbers

8   ICM, iodinated contrast media; ICU, intensive care unit

9   ^ Advanced CKD subgroup is defined as CKD patients with concurrent usage of erythropoietin-

10   stimulating agents.

11   * The HRs were adjusted by the age, sex and comorbidities listed in Table 1.

Median time to dialysis in the advanced CKD subgroup after CT scans

n/N, event numbers/total numbers; Q1-Q3, interquartile range

1 Table 3:
2 Median time to dialysis in the advanced CKD subgroup after CT scans

	CT with ICM N=15	CT without ICM N=84
Dialysis events n/N (%)	11 (73.33%)	64 (76.19%)
Median time, days (Q1-Q3)	12 (4-139)	38 (4-184.5)

5 n/N, event numbers/total numbers; Q1-Q3, interquartile range

Figure 1

Flow diagram for patient selection

Initially, 6998 CKD patients were identified in the studied dataset. Some patients were excluded due to the reasons listed, and there were 1411 patients included for analysis. Subjects were devided into two groups, CT with ICM (487 patients) and CT without ICM (924 patients).

LHID2010, Longitudinal Health Insurance Database 2010 (a dataset derived from National Health Insurance Research Database in Taiwan); ICM, iodinated contrast media

CKD patients in LHID2010
during year 2012-2013
N=6998

Excluded
Age <20 or >100 years old (N=59)
No CT scan during study period (N=5258)
Already on dialysis before CT scan (N=48)
CT scan twice or more in 30 days (N=118)
CT scan plus angiographic procedures in 30 days (N=104)

CKD patients receiving
CT with ICM
N=487

CKD patients receiving
CT without ICM
N=924
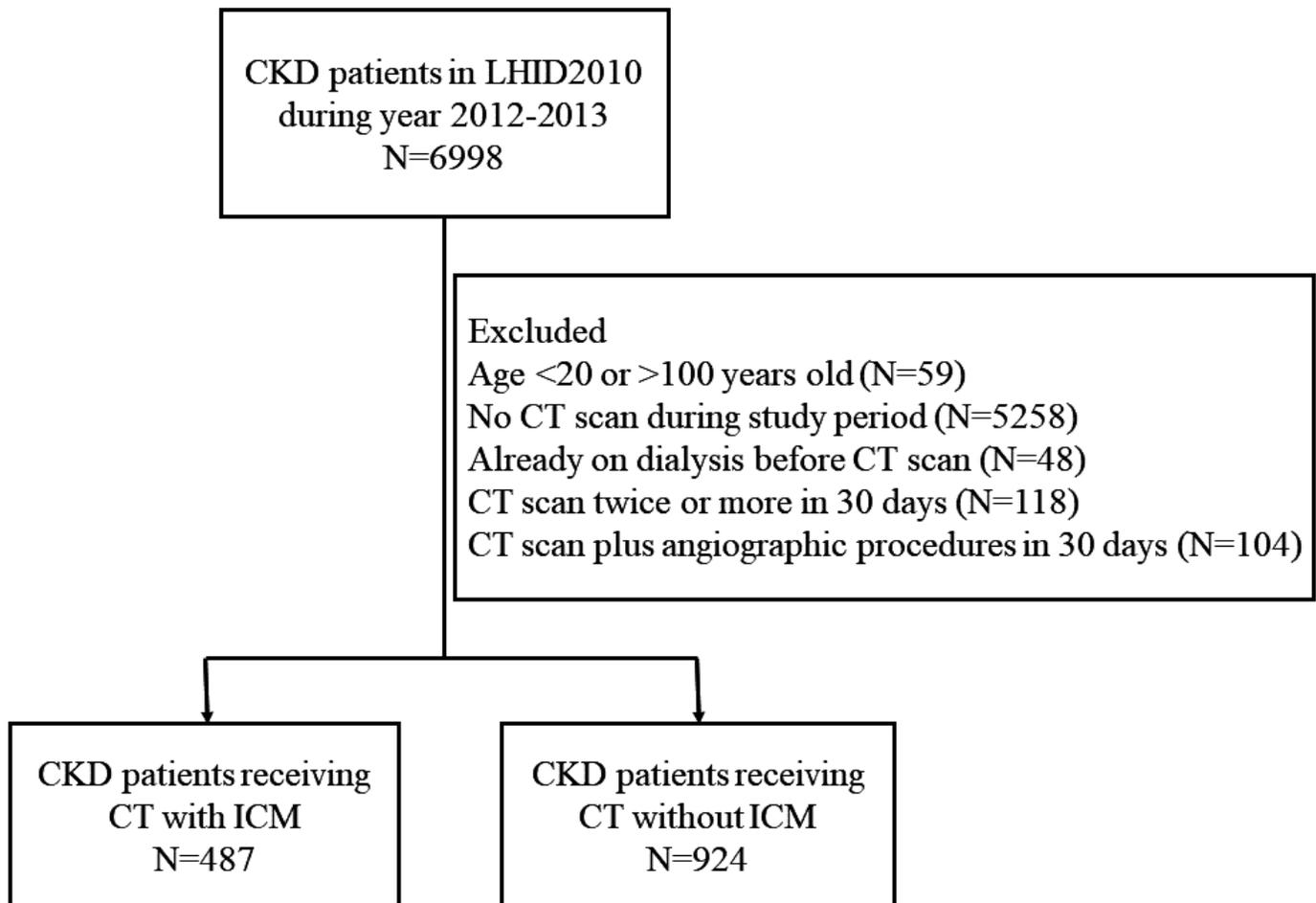
Figure 2

Cumulative incidence of dialysis events within 30 days of CT scans in CKD patients

The Kaplan–Meier curves revealed that the crude cumulative incidence of dialysis within 30 days of CT scans was higher in the CT without ICM group.

ICM, iodinated contrast media

Log Rank P-value=0.0295

— CT with ICM   —— CT without ICM

Cumulative Incidence Rate of Dialysis

Time (Days)