Diagnosis and management of acute kidney injury in patients with cirrhosis: revised consensus recommendations of the International Club of Ascites

Paolo Angeli,1 Pere Gines,2,3,4,5 Florence Wong,6 Mauro Bernardi,7 Thomas D Boyer,8 Alexander Gerbes,9 Richard Moreau,10,11,12 Rajiv Jalan,13 Shiv K Sarin,14 Salvatore Piano,1 Kevin Moore,15 Samuel S Lee,16 François Durand,17,18 Francesco Salerno,19 Paolo Caraceni,7 W Ray Kim,20 Vicente Arroyo,2,3,4 Guadalupe Garcia-Tsao21

INTRODUCTION
Acute renal failure (ARF) is a common complication in patients with decompensated cirrhosis. The traditional diagnostic criteria of renal failure in these patients were proposed in 19961 and have been refined in subsequent years.2 According to these criteria, ARF is defined as an increase

1Unit of Hepatic Emergencies and Liver Transplantation, Department of Medicine—DIMED, University of Padova, Padova, Italy; 2Liver Unit, Hospital Clinic, University of Barcelona, Barcelona, Spain; 3Institut d’Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Barcelona, Spain; 4Centro de Investigación Biomédica en Red en Enfermedades Hepáticas y Digestivas (CIBERHD), Barcelona, Spain; 5Instituto Reina Sofia d’Investigación en Nefrología (IRSN), Barcelona, Spain; 6Division of Gastroenterology, Department of Medicine, University of Toronto, Toronto, Canada; 7Department of Science Medecine e Chirurgie, Alma Mater Studiorum, University of Bologna, Bologna, Italy; 8Department of Medicine, Liver Research Institute, University of Arizona, College of Medicine, Tucson, Arizona, USA; 9Liver Unit, Klinikum Munich, Ludwig Maximilian University of Munich, Munich, Germany; 10Inserm U1149, Centre de recherche sur l’Inflammation (CRI), Paris, France; 11UMR S 1149, Université Paris Diderot, Paris, France; 12DHU UNITY, Service d’hépato-gastro-entérologie, Hôpital Beaujon, APHP, Clichy, France; 13Liver Failure Group, UCL Institute for Liver and Digestive Health, UCL Medical School, Royal Free Hospital, London, UK; 14Department of Hepatology, Institute of Liver and Biliary Sciences, New Delhi, India; 15UCU, Institute of Liver and Digestive Health, Royal Free Campus, University College London, London, UK; 16Liver Unit, University of Calgary, Calgary, Canada; 17Hepatology and Liver Intensive Care Unit, Hospital Beaujon, Clichy, France; 18INSERM U773, Centre de Recherche Biomédicale Bichat Beaujon CRBB, Clichy, France; 19Policlínico IRCCS San Donato, Medicina Interna ed Epato, Università di Milano, Milano, Italy; 20Division of Gastroenterology and Hepatology, Stanford University Medical School, Palo Alto, California, USA; 21Division of Digestive Diseases, Yale University School of Medicine, New Haven, Connecticut, USA
Correspondence to Professor Paolo Angeli, Department of Medicine (DIMED) and Unit of Hepatic Emergencies and Liver Transplantation, University of Padova, Via Giustiniani 2, Padova 35100, Italy; pangeli@unipd.it
The main differences between these new criteria over the conventional criteria in patients with cirrhosis are the following: (1) an absolute increase in sCr is considered; (2) the threshold of sCr ≥1.5 mg/dL (133 μmol/L) is abandoned; and (3) a staging system of AKI, based on a change in sCr over a slightly longer time frame, arbitrarily set at 1 week to enable assessment for progression of stage (modified from AKIN staging) as well as a regression of stage (table 1). AKIN criteria have been shown to be a good predictor of mortality in large cohorts of hospitalized cirrhotic patients, including those in intensive care units and the critically ill. More recently, AKI as diagnosed with AKIN criteria has been shown to be associated with increased mortality in patients with cirrhosis who were hospitalized in regular wards in an AKIN stage-dependent fashion. However, whether these observations can be generalized to patients with cirrhosis who were hospitalized in the intensive care unit awaits further studies.

<table>
<thead>
<tr>
<th>Staging</th>
<th>AKIN criteria</th>
<th>Conventional criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1:</td>
<td>sCr increase ≥1.5 times baseline; or GFR decrease ≥25%; or Anuria; or</td>
<td>Increase in SCr to ≥1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or Urine volume &lt;0.5 mL/kg/h for 6 h; or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L); or Urine output &lt;0.5 mL/kg/h for 6 h; or</td>
</tr>
<tr>
<td>Stage 2:</td>
<td>sCr increase ≥2.0–2.9 times baseline; or GFR decrease ≥50–75%; or Anuria for ≥12 h; or Urine output &lt;0.3 mL/kg/h for ≥24 h; or</td>
<td>Increase in SCr to ≥2.0 mg/dL (133 μmol/L); or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L) within 48 h; or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L) within ≥1.5 times baseline within 48 h; or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L) within ≤1.5 times baseline within 48 h; or</td>
</tr>
<tr>
<td>Stage 3:</td>
<td>sCr increase ≥3.0–4.9 times baseline; or GFR decrease &gt;75%; or Anuria for ≥24 h; or Urine output &lt;0.3 mL/kg/h for ≥48 h; or</td>
<td>Increase in SCr to ≥3.0 mg/dL (263 μmol/L); or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L) within 48 h; or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L) within ≥1.5 times baseline within 48 h; or Increase in SCr by ≥0.3 mg/dL (26.5 μmol/L) within ≤1.5 times baseline within 48 h; or</td>
</tr>
</tbody>
</table>

AKIN, Acute Kidney injury Network; GFR, glomerular filtration rate; KDIGO, Kidney Disease Improving Global Outcome; RIFLE, Risk, Injury, Failure, Loss, End stage renal disease; sCr, serum creatinine.
be generalised to all hospitalised patients with cirrhosis should be assessed in future studies. In fact, as far as the impact of peak AKI stage 1 on in-hospital mortality, it has recently been observed that in patients who developed AKI as a consequence of a bacterial infection, those with stage 1 AKI and a final sCr ≤1.5 mg/dL (133 μmol/L) had a higher short term mortality compared to those without AKI. In addition, regarding regression of AKI stage, it has recently been observed (in non-hospitalised patients) that despite resolution of most AKI episodes in patients with advanced cirrhosis, a gradual and significant increase in sCr and a gradual reduction in mean arterial pressure were observed during follow-up, associated with a significant reduction in mid-term survival compared with non-AKI patients. Indeed, the main lesson learnt from the application of AKIN criteria is that even a small increase in sCr should be identified as early as possible for potential early interventions.

**WHY DO WE NEED TO CHANGE THE CONVENTIONAL DIAGNOSTIC CRITERIA FOR AKI?**

A recent editorial on the topic of AKI in cirrhosis asked the question: “Should we change current definition and diagnostic criteria of renal failure in cirrhosis?” Currently, studies on AKI in patients with cirrhosis showed that AKI defined by an absolute increase in sCr ≥0.3 mg/dL (26.5 μmol/L) and/or ≥50% from baseline is associated with a higher probability of the patients being transferred to the intensive care unit, a longer hospital stay, and an increased in-hospital as well as 90-day and mid-term mortality. On the basis of this evidence, all the experts agreed that it was time to change our current definition of renal failure by introducing a modified version of the KDIGO criteria for the diagnosis of AKI in patients with cirrhosis (table 2). In the new ICA criteria for the diagnosis of AKI, the use of urine output as one of the criteria has been removed since it does not apply to patients with cirrhosis (ie, many patients are oliguric but have preserved kidney function) and it has never been investigated. Further, two other changes to the KDIGO criteria were adopted, namely: (1) a sCr within the last 3 months before admission is considered a baseline value for the diagnosis of AKI when a value within the previous 7 days is not available; and (2) the calculation of the baseline sCr by the reverse application of the Modification of Diet in Renal Disease (MDRD) formula, using an arbitrarily defined normal value of GFR of 75 mL/min/1.73 m², was not included. These two points are specifically discussed in the next section.

**DEFINITION OF BASELINE SERUM CREATININE FOR THE DIAGNOSIS OF AKI**

The first step in applying the ICA-AKI criteria is to define a baseline sCr. It has been stated that a renal disease process that results in a change in sCr over several weeks cannot be defined as AKI, although it may still represent an important clinical entity. Nevertheless, as with any clinical scenario, the timeframe for the definition of AKI is somewhat arbitrary, and it is mainly suitable for the diagnosis of AKI in hospitalised patients using a sCr value on or after admission as baseline (hospital-acquired AKI). However, as in the general population, many patients with cirrhosis can develop AKI before admission to hospital (community-acquired AKI). Indeed, in previous studies where pre-admission values of sCr were used as baseline, the rate of AKI was higher than in those based on sCr on admission as baseline (47% vs 26%). Thus, the diagnosis of community-acquired AKI on admission is related to two possible scenarios: (1) the patient with an available sCr value before admission; and (2) the patient without an sCr value before admission. The use of pre-admission values of sCr poses a great dilemma: how far back can a baseline value of sCr be retrieved and still be expected to be ‘valid’ for the definition of AKI? In the general population, it is reasonable to assume that sCr will be stable over several months or even years, so that an sCr obtained 6 months or even 1 year previously would reasonably reflect the patient’s premorbid baseline.

In patients with cirrhosis, an application of a more rigorous time frame for the definition of AKI seems even more important. In fact, in these patients, impairment of renal function may progress gradually as they go from a compensated to a decompensated state and then more rapidly as the decompensated state worsens. In addition, it should be considered that almost all patients with cirrhosis and ascites receive diuretics that can transiently impair renal function and, thus, increase sCr.

Furthermore, it is important to emphasise the variability in sCr measurements from laboratory to laboratory or even within the same laboratory due to, for example, fluctuations in serum bilirubin in patients with cirrhosis. A sCr obtained <7 days before admission would be the ideal condition to use the ICA-AKI criteria, but this timeframe seems unfeasible in most cases. Thus, taking into account the previous experiences, we conclude that use of the last value of sCr within the last 3 months before admission seems to be the most reasonable definition of the baseline sCr value.

**Table 2 International Club of Ascites (ICA-AKI) new definitions for the diagnosis and management of AKI in patients with cirrhosis**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline sCr</td>
<td>A value of sCr obtained in the previous 3 months, when available, can be used as baseline sCr. In patients with more than one value within the previous 3 months, the value closest to the admission time to the hospital should be used. In patients without a previous sCr value, the sCr on admission should be used as baseline.</td>
</tr>
<tr>
<td>Definition of AKI</td>
<td>Increase in sCr ≥0.3 mg/dL (26.5 μmol/L) within 48 h or a percentage increase in sCr ≥50% from baseline which is known, or presumed, to have occurred within the prior 7 days.</td>
</tr>
<tr>
<td>Staging of AKI</td>
<td>Stage 1: increase in sCr ≥0.3 mg/dL (26.5 μmol/L) or an increase in sCr ≥1.5-fold to twofold from baseline. Stage 2: increase in sCr ≥two to threefold from baseline. Stage 3: increase of sCr &gt;3-fold from baseline or sCr ≥4.0 mg/dL (353.6 μmol/L) with an acute increase ≥0.3 mg/dL (26.5 μmol/L) or initiation of renal replacement therapy.</td>
</tr>
<tr>
<td>Progression of AKI</td>
<td>Regression of AKI to a lower stage.</td>
</tr>
<tr>
<td>Response to treatment</td>
<td>No response. Full response. Partial response. No regression of AKI. Regression of AKI stage with a reduction of sCr to ≥0.3 mg/dL (26.5 μmol/L) above the baseline value.</td>
</tr>
</tbody>
</table>

AKI, acute kidney injury; RRT, renal replacement therapy; sCr, serum creatinine.
more feasible. In this scenario, a community-acquired AKI may be diagnosed in the case of an increase in sCr ≥50% from the last sCr value (table 2). For patients without an available sCr before hospitalisation, the use of an estimated value of sCr as the baseline, calculated by the reverse application of the MDRD formula using a predetermined value of GFR (75 mL/min), has been suggested for the general population of patients. However, it is well known that the MDRD formula is inaccurate in the estimation of GFR in patients with cirrhosis, particularly in those with ascites. As a result, its reverse application in these patients may only add further biases. Preliminary data from the Padua centre suggest that a diagnosis of AKI based on an estimated GFR <60 mL/min on admission (Angeli P et al, unpublished observations). However, among patients without an sCr value before admission, one scenario deserves specific mention, and that is the case of the patient with an sCr ≥1.5 mg/dL (133 μmol/L) at admission. The management of such a patient should be based not only on a formal definition of AKI, but also on clinical judgment. Therefore, in a patient with impairment of renal function and a clearly identifiable precipitating event, it would be reasonable to assume that the renal failure represents AKI. Alternatively, the initial sCr may be used as the baseline value, and if AKI criteria are met subsequently then the patient has AKI. This approach was commonly used previously for the diagnosis of type 1 HRS.

A NEW ALGORITHM FOR THE MANAGEMENT OF AKI IN PATIENTS WITH CIRRHOSIS

According to the new ICA-AKI diagnostic criteria for AKI, we propose a new algorithm for the management of AKI in patients with cirrhosis (figure 1). The algorithm is based on the new staging of AKI.

We recommend that patients with cirrhosis and ascites with initial ICA-AKI stage 1 should be managed as soon as possible with the following measures:

1. Review drug chart: review of all medications (including over-the-counter (OTC) drugs), reduction or withdrawal of diuretic therapy, withdrawal of all potentially nephrotoxic drugs, vasodilators or non-steroidal anti-inflammatory drugs (NSAIDs)

2. Plasma volume expansion in patients with clinically suspected hypovolaemia (with crystalloids or albumin or blood (in patients who had AKI as a result of gastrointestinal bleeding) according to clinical judgment)

3. Prompt recognition and early treatment of bacterial infections when diagnosed or strongly suspected.

Patients who respond with a return of sCr to a value within 0.3 mg/dL (26.5 μmol/L) of the baseline value should be followed closely (assessment of sCr every 2–4 days during the hospitalisation and checked as outpatients at least every 2–4 weeks during the first 6 months after the discharge) for early identification of potential new episodes of AKI. In those cases where there is progression of the AKI stage, the patients should be treated as patients who present with ICA-AKI stage 2 and 3. This treatment should include the withdrawal of diuretics, if this had not been previously implemented, as well as the expansion of plasma volume with intravenous albumin at the dose of 1 g per kg bodyweight per day for two consecutive days, in order to treat pre-renal AKI and to allow differential diagnosis of AKI (box 1). The maximal dose per day of albumin should not exceed 100 g as previously suggested.

Further management of patients who do not respond to diuretic withdrawal and plasma volume expansion will obviously lead to:

Resolution

Stable

Progression

Close follow up

Further treatment of AKI decided on a case-by-case basis §

Specific treatment for other AKI phenotypes

Vasoconstrictors and albumin

Figure 1  Proposed algorithm for the management of acute kidney injury (AKI) according to International Club of Ascites—AKI (ICA-AKI) classification that combines Kidney Disease Improving Global Outcomes (KDIGO) criteria and conventional criteria in patients with cirrhosis and ascites. Most of the experts had concerns about the use of vasoconstrictors in patients with AKI stage 1 and sCr <1.5 mg/dL. For the definition of close follow-up, and/or case-by-case, see the text. *Treatment of spontaneous bacterial peritonitis should include albumin infusion according to current guidelines. #Initial AKI stage is defined as AKI stage at the time of first fulfilment of the AKI criteria. §No global consensus was reached on this point. HRS, hepatorenal syndrome; NSAIDs, non-steroidal anti-inflammatory drugs; sCr, serum creatinine.

Angeli P, et al. Gut April 2015 Vol 64 No 4
The definition of type 1 HRS. The potential advantage of the algorithm is that its application may allow earlier treatment of patients with type 1 HRS, leading to a better outcome as compared with the current approach. However, we lack studies where vasoconstrictors were used in the treatment of HRS with lower values of sCr, and caution should be exercised in the use of vasoconstrictors in these patients pending further controlled trials.

Nevertheless, all the experts agreed on the removal of the fixed cut-off value of sCr from the diagnostic criteria of HRS. This is the only change that they wanted to introduce in the current diagnostic criteria for HRS. As a consequence, all the remaining criteria are maintained (box 1). However, these criteria do not rule out the possibility of renal parenchymal damage.33 All the experts agreed on the potential role of new urinary biomarkers in the differential diagnosis of the different types of AKI in patients with cirrhosis. Several urinary biomarkers of tubular damage, such as neutrophil gelatinase-associated lipocalin (NGAL), kidney injury molecule-1 (KIM-1), interleukin-18 (IL-18), and liver fatty acid-binding protein (L-FABP), have been discovered in recent years. Preliminary experiences from Europe and the USA showed that the use of NGAL36 and/or the combination of urinary biomarkers (NGAL, KIM-1, IL-18, L-FABP and albuminuria)37 may be useful in the differential diagnosis of AKI in patients with cirrhosis. These findings need to be confirmed in future studies.

The removal of a fixed cut-off value of sCr from the diagnostic criteria of HRS in the setting of AKI has important implications in the management of these patients. Thus, there is a need to change the definition of response to the pharmacologic treatment of HRS. Full response will be defined by return of sCr to a value within 0.3 mg/dL (26.5 μmol/L) of the baseline value. Partial responses will be defined by a regression of at least one AKI stage with a fall in the sCr value to ≥0.3 mg/dL (26.5 μmol/L) above the baseline value. Nevertheless, we should recognise that preliminary data suggest that even a partial decrease of sCr from baseline may be associated with improved short term survival, irrespective of whether or not the patient achieves HRS reversal (sCr <1.5 mg/dL).38 These data suggest that the degree of improvement in sCr may be more relevant than achieving a finite level of renal function.

### Box 1 Diagnostic criteria of hepatorenal syndrome (HRS) type of acute kidney injury (AKI) in patients with cirrhosis

**HRS-AKI**

- Diagnosis of cirrhosis and ascites
- Diagnosis of AKI according to ICA-AKI criteria
- No response after 2 consecutive days of diuretic withdrawal and plasma volume expansion with albumin 1 g/kg bodyweight
- Absence of shock
- No current or recent use of nephrotoxic drugs (NSAIDs, aminoglycosides, iodinated contrast media, etc)
- No macroscopic signs of structural kidney injury*, defined as:
  - absence of proteinuria (>500 mg/day)
  - absence of microhaematuria (>50 RBCs per high power field)
  - normal findings on renal ultrasonography

* Patients who fulfil these criteria may still have structural damage such as tubular damage. Urine biomarkers will become an important element in making a more accurate differential diagnosis between HRS and acute tubular necrosis.

ICA, International Club of Ascites; NSAIDs, non-steroidal anti-inflammatory drugs; RBCs, red blood cells.
CONCLUSIONS AND FUTURE PERSPECTIVES

Based on the most recent studies on AKI in patients with cirrhosis and ascites, a new algorithm for the management of AKI in these patients is proposed for clinical practice and for future research. The main innovative aspects of this new algorithm are the following:

- The adoption of the main point derived from the application of the KDIGO criteria in the definition of AKI in patients with cirrhosis, namely, use of dynamic changes of SCR.
- A more structured diagnostic process, in order to allow a rational application of the therapeutic resources, avoiding potentially undesirable consequences of overtreatment of AKI as a result of indiscriminant use of KDIGO criteria.
- The definitive removal of any cut-off value of SCR from the criteria for diagnosis of HRS in the setting of AKI, but maintaining the remaining previous criteria (box 1).

Several issues remain to be addressed: (1) the impact of the management of AKI according to the new algorithm on the outcome of these patients should be tested in future prospective studies; and (2) the role of the new biomarkers of renal tubular damage in predicting the progression and prognosis of AKI, and in the differential diagnosis of the different types of AKI. 36 37

In summary, the results of the latest consensus conference of the ICA introduces a new dynamic definition of AKI in patients with cirrhosis, on which a new treatment algorithm is based, representing a substantial change from the traditional criteria used until now in the definition of AKI and type 1 HRS.

Contributors

Organisation of the meeting: PA. Analysis of data from the literature: PA, PG, FW, MB, TDB, AG, RM, RJ, SKS, SP, KM, MSS, FD, FS, PC, WRK, VA, GG. Drafting and writing the manuscript: PA, PG, FW, MB, SP, GG. Critical review of data and manuscript revision: PA, PG, FW, MB, TDB, AG, RM, RJ, SKS, SP, KM, MSS, FD, FS, PC, VA, GG. Funding: PG. Research funding from Sequana Medical, Grifols SA; Consultantcy Advisory to Ferring Pharmaceuticals; Competitive Public Grant Funding from: Fondos de Investigación Instituto de Salud Carlos III (FIS12/0380) and Agencia de Gestión d’Ajuds Universitaris i de Recerca (2014 SGR 708). MB: Consultant to CSL Behring GmbH, Baxter Healthcare SA; speaker to Behring GmbH, Baxter Healthcare SA, PPTA Europe. AG: Consultant to CSL Behring. RJ: Consultant to Oceca Therapeutics Inc, Conatus Pharmaceuticals Inc; Research grant from: Grifols Inc, Gambro AB, Sequana Medical AG, Norgine BV, Oceca Therapeutics Inc (the latter five companies are all involved in research collaboration); Speaker to Grifols Inc; Norgine BV; Inventors of Ornithine Phenylacetate licensed by UCL to Oceca Therapeutics; UCL spinout Yyaqit which will in-licence five of the following inventions in which R Jalan is the main inventor: YAO001 nanoporous carbons for prevention of gut bacterial translocation, UCL liver dialysis device, DASIMAR biomarker for liver failure, Neutrophil for test: biomarker for predicting infection in decompensated cirrhosis. Urinary toll-like receptor 4: for differential diagnosis of renal dysfunction of cirrhosis. SSL: Consultant to Ikaria and Grifols. PC: Lecturer to Baxter Healthcare SA, Kedrion, Grifols. VA: Received grant and research support from Grifols.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

Editors’ note This article is being published jointly in Gut and Journal of Hepatology.


Received 20 November 2014
Revised 4 December 2014
Accepted 11 December 2014
Published Online First 28 January 2015
Gut 2015;64:531–537.

doi:10.1136/gutjnl-2014-308874

REFERENCES


