Acute Kidney Injury; get the basics right first!

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University Hospital Aintree (UHA),
Liverpool, UK
Acute kidney injury (AKI)

- Why a new definition for acute kidney injury (AKI)?
- RIFLE classification; shooting well?
- Acute kidney Injury Network classification
- Non-dialytic treatment; Prevention better than cure
- How are we faring? The UK data – UHA, ICU, HES and NCEPOD
- Proposed AKI guideline
- Conclusion
Why a new definition of AKI?

- Acute renal failure (ARF): ‘classic’ ARF v ‘acute on chronic renal failure’. No uniform and precise operational definition
- Even modest increase in serum creatinine 26.4 µmol/L is associated with a dramatic impact on the risk of mortality – hence ‘acute kidney injury’

Why a new definition of AKI?

- 19,982 hospitalised patients, 9,205 patients with > 1 creatinine rise in creatinine

<table>
<thead>
<tr>
<th>Rise in creatinine</th>
<th>Multivariable Odds Ratio (mortality)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 0.3 mg/dl (26.4 µmol/L)</td>
<td>4.1</td>
</tr>
<tr>
<td>≥ 0.5 mg/dl (44.2 µmol/L)</td>
<td>6.5</td>
</tr>
<tr>
<td>≥ 1.0 mg/dl (88.4 µmol/L)</td>
<td>9.7</td>
</tr>
<tr>
<td>≥ 2.0 mg/dl (176.8 µmol/L)</td>
<td>16.4</td>
</tr>
</tbody>
</table>

Why a new definition?

- Despite advancement in haemodialysis techniques, there is no improvement in AKI mortality.
- Over 30 definitions in the literature
  It still remains enigmatic and debated subject
    - Incidence 1 to 31%
    - Mortality 19-83%
    - What is the most optimal prevention and treatment?

Acute renal failure – definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group
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Abstract

Introduction There is no consensus definition of acute renal failure (ARF) in critically ill patients. More than 30 different definitions have been used in the literature, creating much confusion and making comparisons difficult. Similarly, strong debate exists on the validity and clinical relevance of animal models of ARF; on choices of fluid management and of end-points for trials of new interventions in this field; and on how information technology can be used to assist this process. Accordingly, we sought to review the available evidence, make recommendations and delineate key questions for future studies.

Methods We undertook a systematic review of the literature using Medline and PubMed searches. We determined a list of key questions and convened a 2-day consensus conference to develop summary statements via a series of alternating breakout and plenary sessions. In these sessions, we identified supporting evidence and generated recommendations and/or directions for future research.

Results We found sufficient consensus on 47 questions to allow the development of recommendations. Importantly, we were able to develop a consensus definition for ARF. In some cases it was also possible to issue useful consensus recommendations for future investigations. We present a summary of the findings. (Full versions of the six workgroups’ findings are available on the internet at http://www.ADQI.net)

Conclusion Despite limited data, broad areas of consensus exist for the physiological and clinical principles needed to guide the development of consensus recommendations for defining ARF, selection of animal models, methods of monitoring fluid therapy, choice of physiological and clinical end-points for trials, and the possible role of information technology.

Keywords: acute renal failure, animal models, creatinine, glomerular filtration rate, information technology, intravenous fluids, kidney, outcome research, randomized controlled trials, urea
RIFLE classification

<table>
<thead>
<tr>
<th>GFR Criteria*</th>
<th>Urine Output Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased sCr x 1.5 or GFR decrease &gt; 25%</td>
<td>UO &lt; .5 ml/kg/h x 6 hr</td>
</tr>
<tr>
<td>Increased sCr x 2 or GFR decrease &gt; 50%</td>
<td>UO &lt; .5 ml/kg/h x 12 hr</td>
</tr>
<tr>
<td>Increase sCr x 3, GFR decrease 75% or sCr ≥ 4 mg/dl, Acute rise ≥ 0.5 mg/dl</td>
<td>UO &lt; 0.3 ml/kg/h x 24 hr or Anuria x 12 hrs</td>
</tr>
<tr>
<td>Persistent ARF** = complete loss of kidney function &gt; 4 weeks</td>
<td>Oliguria</td>
</tr>
<tr>
<td>ESKD</td>
<td>End Stage Kidney Disease (&gt; 3 months)</td>
</tr>
</tbody>
</table>
RIFLE predicts mortality!

- Meta-analysis of 24 studies in which the RIFLE classification was used to define AKI were performed.
- Over 71,000 patients were included in the analysis.
- It seems to be a good outcome predictor, with a progressive increase in mortality with worsening RIFLE class.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Injury</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR of mortality v Non-AKI</td>
<td>2.4</td>
<td>4.15</td>
</tr>
</tbody>
</table>

P<0.0001 for all

Controversies about RIFLE

- **Increase in serum creatinine**
  - Dependency on baseline creatinine values of patients
  - Reliability of calculated baseline creatinine by MDRD formula (assumption of eGFR 75 if no baseline)
  - 1-7 days (subacute)

- **Reduced urinary output**
  - Fluctuations in urine output depending on volume status, obstruction etc.

- **Renal replacement therapy (RRT)**
  - Influence of requirement of RRT on RIFLE stage
  - Applicability of RIFLE as prognostic tool in patients with severe sepsis requiring RRT
  - Applicability of RIFLE stage for initiation of RRT
Acute Kidney Injury Network 2005

Professional Societies
- American College of Chest Physicians
- American Society of Nephrology
- American Society of Paediatric Nephrology
- American Thoracic Society
- Asia Pacific Association of Critical Care Medicine
- Asia Pacific Society of Nephrology
- Australia and New Zealand Intensive Care Society
- Brazilian Intensive Care Society
- Canadian Critical Care Society
- Chinese Society of Nephrology
- European Dialysis and Transplant Society
- European Society of Intensive Care Medicine
- Indian Society of Nephrology
- International Paediatric Nephrology Association
- International Society of Nephrology
- National Kidney Foundation
- Sociedade Latino-American de nefrologia e hypertensao
- Societe de reanimation de langue de francaise
- Society of Critical Care Medicine

Guideline development, organisation and policy and funding agencies
- Acute Dialysis Quality Initiative
- Kidney disease: Improving global outcome
- National Insititute of Diabetes and Digestive and Kidney Diseases

Practitioners
Nephrology
Critical Care Medicine
Paediatrics.

Research
Basic Science
Translational
Clinical

May;3(3):887-94
Research

Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury

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Abstract

Introduction Acute kidney injury (AKI) is a complex disorder for which currently there is no accepted definition. Having a uniform standard for diagnosing and classifying AKI would enhance our ability to manage these patients. Future clinical and translational research in AKI will require collaborative networks of investigators drawn from various disciplines, dissemination of information via multidisciplinary joint conferences and publications, and improved translation of knowledge from preclinical research. We describe an initiative to develop uniform standards for defining and classifying AKI and to establish a forum for multidisciplinary interaction to improve care for patients with or at risk for AKI.

Methods Members representing key societies in critical care and nephrology along with additional experts in adult and pediatric AKI participated in a two day conference in Amsterdam, The Netherlands, in September 2005 and were assigned to one of three workgroups. Each group’s discussions formed the basis for draft recommendations that were later refined and improved during discussion with the larger group. Disagreeing opinions were also noted. The final draft recommendations were circulated to all participants and subsequently agreed upon as the consensus recommendations for this report. Participating societies endorsed the recommendations and agreed to help disseminate the results.

Results The term AKI is proposed to represent the entire spectrum of acute renal failure. Diagnostic criteria for AKI are proposed based on acute alterations in serum creatinine or urine output. A staging system for AKI which reflects quantitative changes in serum creatinine and urine output has been developed.

Conclusion We describe the formation of a multidisciplinary collaborative network focused on AKI. We have proposed uniform standards for diagnosing and classifying AKI which will need to be validated in future studies. The Acute Kidney Injury Network offers a mechanism for proceeding with efforts to improve patient outcomes.
Acute Kidney Injury Network -
Diagnostic Criteria for Acute Kidney Injury (AKI)

An abrupt (within 48 hours) reduction in kidney function defined as

an absolute increase in serum creatinine of more than or equal to ≥ 26.4 μmol/l (0.3 mg/dl), or

a percentage increase in serum creatinine of ≥ 50% (1.5-fold from baseline),

or a reduction in urine output of ≤ 0.5 ml/kg per hour for > six hours.

Mehta et al, Critical Care Med 2007; 11: R31
<table>
<thead>
<tr>
<th>Stage</th>
<th>Serum creatinine criteria</th>
<th>Urine output criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increase in serum creatinine by ≥ 0.3mg/dl (≥26.4 µmol/L) Or Increase ≥ 150-200% from baseline</td>
<td>Urine output &lt; 0.5ml/kg/hr &gt; 6 hr</td>
</tr>
<tr>
<td>2</td>
<td>Increase in serum creatinine &gt; 200-300% from baseline</td>
<td>Urine output &lt; 0.5ml/kg/hr &gt; 12 hr</td>
</tr>
<tr>
<td>3</td>
<td>Increase in serum creatinine &gt; 300% from baseline Or Serum creatinine &gt; 4mg/dl (≥354 µmol/L) with an acute rise of &gt; 44.2 µmol/L Or Treatment with renal replacement therapy</td>
<td>Urine output &lt; 0.3ml/kg/hr x 24 hr Or Anuria x 12 hr</td>
</tr>
</tbody>
</table>

Mehta et al, Critical Care Med 2007; 11: R31
ATN - prevention

- Contrast induced nephropathy (CIN) – increase of serum creatinine > 44.2µmol/L or 25% from baseline

- High risk patients (DM, CKD, CCF, RAS, Elderly)

- Non-ionic iso-osmolal contrast

- N-Acetylcysteine and saline. Meta-analysis of 30 trials suggest benefit over saline alone. However surrogate endpoint CIN.

- Stop NSAIDs/Diuretics/Metformin/ ACEI/ARB temporarily if no contraindication

- Saline / Isotonic sodium bicarbonate hydration (1 trial)

ATN - prevention

- Tumour lysis syndrome (TLS)
- Precipitation of urate crystals in tubules with 2° ATN.
- Allopurinol (inhibiting the enzyme xanthine oxidase) prevents formation of uric acid but does not degrade it.
- Rasburicase = recombinant urate oxidase converts urate to allantoin (5x more soluble)
- Forced alkaline diuresis
Rasburicase v Allopurinol in TLS

Non-Dialytic Treatment of ATN

- Fluid Resuscitation - Improved tubular Na\(^+\) and H\(_2\)O delivery reduces Na\(^+\) reabsorption and hence tubular O\(_2\) consumption

- Crystalloid v colloid – no benefit one over the other

SAFE study

Multicenter RCT-
Similar outcome between 4% albumin and saline in ICU patients


Figure 1. Kaplan–Meier Estimates of the Probability of Survival.
P=0.96 for the comparison between patients assigned to receive albumin and those assigned to receive saline.
Diuretics – theoretical benefits

Loop diuretics reduce tubular $O_2$ consumption.

Osmotic diuretics flush out tubular debris.

All diuretics increase $Na^+$ to the JGA → afferent artery vasodilation.

? Loop diuretics reduce tubular cell apoptosis.
Loop Diuretics

92 patients in ITU with AKI.
all received mannitol and dopamine.
± frusemide or torasemide 3 mg/kg 6 hourly.

Loop diuretics increased UO put no affect on survival,
dialysis, duration ATN.
Non-significant increase in deaths in diuretic groups.

Shilliday et al, Nephrol Dial Transplant, 1997;12(12):2592-6
Loop Diuretics

Retrospective study of 552 with AKI referred to nephrology.

326 had received diuretics prior to referral
Diuretic group were 1.8× more likely to die

Mehta et al JAMA 2002;288:2547-53 and
(with Chertow) JAMA, 2003;289:1379-81
Diuretic boluses v infusions

RCT, 100 pts, post cardiac surgery, AKI. Different drugs in two limbs (furosemide, bumetadine, and ethracrynic acid) v (mannitol, furosemide, and dopamine) No defined doses No ‘no-diuretic’ limb

But
Infusions lead to more diuresis, less dialysis (90% v 6%) and shorter ATN.

Meta-analysis demonstrated no benefit in the use of Frusemide in AKI

KM Ho  BMJ 2006; 26;333:420.
Dopamine

ATN is associated with severe renal vasoconstriction

Low dose dopamine ‘renal dose’
(2-3mcg/kg/min) is a selective renal vasodilator and loop diuretic
Dopamine

  328 ITU patients with ATN
  Randomised to dopamine 2 μg/kg/min or placebo
  Other diuretics as per clinician
  No difference in urine output, RRT or se Cr > 300


Also.........Meta-analysis demonstrated no benefit!

University Hospital Aintree: AKI

- 238 hospitalised patients were referred to nephrology department over 6 months.
- 166 had AKI and 72 patients did not have AKI.
- AKI 1 was noted in 43%, AKI 2 in 18% and AKI 3 in 39%.
- The most common comorbidity for the AKI group was hypertension (45%), followed by IHD (37%), LVF (34%), diabetes (32%) and malignancy (22%).
- The most common cause of AKI was sepsis (35.5%).
- Ten percent of AKI group required acute intermittent haemodialysis. Only 3% remained dialysis dependent.
- The most common cause of death in the AKI group was sepsis (n=33, 19.9%), followed by cardiac (n=16, 9.6%) and malignancy (n=11, 6.6%).

MS Ahmed et al (ASN poster presentation 2008)
Intensive Care Unit (ICU) data - AKI

- 22,303 patients admitted to 22 ICU in UK and Germany

<table>
<thead>
<tr>
<th></th>
<th>No AKI</th>
<th>AKI 1</th>
<th>AKI 2</th>
<th>AKI 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU mortality</td>
<td>10.7%</td>
<td>20.1%</td>
<td>25.9%</td>
<td>49.6%</td>
</tr>
<tr>
<td>Hospital mortality</td>
<td>16.9%</td>
<td>29.9%</td>
<td>35.8%</td>
<td>57.9%</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Ostermann et al, Critical Care 2008;12:R144
Long term outcome of AKI

- 206 ICU patients with AKI were randomized in a trial comparing haemofiltration versus haemodiafiltration.
- 95 (46%) survived at 90 days.
- Post-discharge information relating to 3-year survival and renal function was successfully obtained in 89 (94%) of the patients.
- Of the 89 patients studied, chronic kidney disease (CKD) was present in 32 subjects from the onset, and CKD developed de novo in 25 patients following AKI.
- End-stage renal disease developed in 9 patients (of whom 8 had pre-existing CKD) and 29 patients died.
- Three-year survival was 67% overall; the mortality at 3 years was 50% for those with pre-existing kidney disease, and 71 and 82% for those with de novo and without CKD, respectively.

Triverio et al Nephrol Dial Transplant 2009; 24 (7): 2186-89

Kaplan–Meyer analysis of 3-year survival rates in patients without (no CKD prior to AKI) and with prior (prior CKD to AKI) or de novo CKD after AKI.
Key Findings on Hospital Episode Statistic (HES) renal reference group data

- All adult medical admissions in England 06/07
- Pilot – 4 networks, 16 trusts.
- ICD renal codes identified
- Majority with renal diagnoses are managed by non renal teams, especially emergencies.
- 60% of acute trusts do not have onsite renal teams, but manage similar numbers of renal patients.
- Higher mortality in centres without a renal service.

KA Abraham et al, University Hospital Aintree (Renal Association poster presentation 2009)
Adding Insult to Injury

A review of the care of patients who died in hospital with a primary diagnosis of acute kidney injury (acute renal failure).
Patient sample

**Inclusion criteria**
- Patients aged 16 years or older
- Coded for a diagnosis of AKI
- Who died in hospital between January 1\(^{st}\) 2007 and March 31\(^{st}\) 2007 inclusive

**Exclusion criteria**
- Patients already on RRT
- Admission was for palliative care

www.ncepod.org.uk
Data collection and assessment

Clinical questionnaire
Organisational questionnaire
Casenote extracts
Advisor assessment – Multidisciplinary group that reviewed the anonymised casenote extracts and questionnaires

Figure 2.1 Data returns

1518 cases identified

1045 cases included

473 cases* excluded

* Excluded cases were those cases that upon review of the casenotes it was judged by the local clinician or advisor that the patient did not have evidence of AKI.

69 *blank returns

976 cases included

Questionnaire and casenotes returned 587 (60%)

Casenotes only returned 55 (6%)

Questionnaire only returned 58 (6%)

No data returned 276 cases (28%)

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Key findings from NCEPOD

- Only 50% of AKI care considered good
- Poor assessment of risk factors of AKI
- Unacceptable delay in recognition of post-admission in AKI in 43%
- 22 patients died with a primary diagnosis of post-admission AKI which was predictable and avoidable
- 33% of patients had inadequate investigations
- 29% had inadequacies in clinical management
- Poor recognition of acute illness, hypovolaemia and sepsis

www.ncepod.org.uk
Key Findings from NCEPOD

-A third of patients were referred to a nephrologist

-A fifth of referrals were delayed

-20% of patients not referred should have been

-69% of patients who were referred to nephrologists received good care
Key findings from NCEPOD

- More than half of acute admitting hospitals did not have on-site nephrologists.
- 39% of all hospitals without nephrologists the nearest nephrologist was in a different city.
- Not all hospitals have access to 24 hour ultrasound or nephrostomy service.

www.ncepod.org.uk
Key findings from NCEPOD

- 139/549 patients did not have adequate senior reviews. Quality of care in this group was judged to be less good.

- 113 patients were transferred to renal/critical care. An additional 44 patients should have received step up care.

- Quality of care in those 44 patients was judged to be very poor.

www.ncepod.org.uk
Key findings from NCEPOD

- 67/551 (12%) patients received RRT
- Advisors felt that 36/427 (8%) patients who did not receive RRT should have done so
- Older patients received less RRT Above the age of 85 years RRT was infrequent
- Treatment limitation decisions were made in 52% of cases. Patient involvement was low

www.ncepod.org.uk
Recommendations from NCEPOD

- Initial clerking for all emergency patients should include an AKI risk assessment
- All emergency patients should have electrolytes checked on admission and appropriately thereafter
- Predictable and avoidable AKI should never occur
- NICE Clinical Guideline (CG) 50 should be disseminated and implemented
- Trusts need to ensure that NICE CG 50 has been implemented with annual audit of serious adverse events

www.ncepod.org.uk
A safety net?

NICE CG 50
- Track and trigger system
- Appropriate response
- Critical care outreach

www.ncepod.org.uk

www.nice.org.uk
Recommendations from NCEPOD

- All acute admitting hospitals should have access to either onsite nephrologists or a dedicated service within reasonable distance.
- All acute admitting hospitals should have access to 24 hour ultrasound and nephrostomy service, including weekends.
- Early recognition of at risk patients should allow patient involvement in treatment limitation decisions before this opportunity is missed.
- Treatment limitation decisions should be made with reference to General Medical Council guidance and within the legislative framework of the Mental Capacity Act.

www.ncepod.org.uk
Recommendations from NCEPOD

- All acute admissions should receive adequate senior reviews (with a consultant review within 12 hours of admission)
- There should be sufficient renal and critical care beds to allow rapid step up in care if appropriate

- A nephrology referral should be followed by prompt senior advice, and review where appropriate. Renal registrars should discuss all referrals with their consultant

- All trusts should have written guidelines to ensure an effective interface between ITU, renal units and general wards

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Conclusion from NCEPOD

- Systematic failings in AKI

-Failures in:
  - Recognition and management of AKI
  - Recognition and management of complications
  - Referral and support

-Failures in recognition of the acutely ill

-Education
  - Illness severity
  - Risk of AKI
  - Precipitants
  - Early management

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Initial assessment:

**MEWS** (Modified Early Warning System)

Urgent U&Es and repeat within 48 hours

Follow NICE clinical guideline 50 for acutely ill patients

- Any Acute illness
- Oliguria / Anuria

**Confirmed AKI**

- Treat underlying problems (e.g. hypotension, dehydration, sepsis)
- Monitor MEWS (Pulse, BP, Respiratory Rate, Temperature, Urinary Output)
- Treat acute complications (e.g. acidosis, hyperkalemia, respiratory failure)
- Urine dip test and microscopy
- Stop any nephrotoxic drugs e.g. NSAID, ACEI, A2RB, diuretics. Avoid gentamicin / contrast
- Withhold anti-hypertensives if hypotensive
- Urinary catheter and strict fluid balance; intake/output monitoring
- Urgent renal ultrasound scan
- Urgent senior review
- Daily U & Es

**AKI stage 1**

Treat underlying problems (hypotension, dehydration, sepsis etc)

Treat acute complications (acidosis, hyperkalemia, respiratory failure)

- Consider renal screen (ANCA, Anti GBM Ab, ANA, dsDNA, Immunoglobulins & paraprotein, urine BJP)

- **If no improvement:** consider renal referral

**AKI stage 2**

Same as AKI Stage 1

- Also, urgent renal screen
- Consider renal referral

**AKI stage 3**

Same as AKI stage 2

- Refer renal
- Urgent Hep B/ Hep C/HIV (predialysis screen)
Conclusion – AKI; Get the basics right first!

- AKI confers an independent mortality
- Early recognition and intervention are essential.
- Prevention of AKI is better than cure!
- Urgent need to rectify the lack of clinical care reported by NCEPOD
- Recognition and resuscitation of the acutely ill patient is essential (NICE CG 50)
Conclusion – AKI; Get the basics right first!

- NCEPOD report has major medical education, training, organisation and resource implications
- Development of an AKI guideline would be important for the acute physicians
- The refined RIFLE aka AKIN classification, being a universal classification will help us research and discover the best strategy/treatment to prevent and treat AKI.
References

- Triverio et al. Nephrol Dialysis Transplant 2009 24(7):2186-2189
- Ostermann et al, Critical Care 2008;12:R144
- Bellomo et al. Critical Care 2004; 8: R204-R212
References

- Mehta et al. Critical Care 2007; 11: R31
- Perel et al. Colloids versus crystalloids for fluid resuscitation in critically ill patients. Cochrane Database of Systematic Reviews 2008
References

• Mehta et al. JAMA 2002;288:2547-53 and (with Chertow) JAMA, 2003:289:1379-81
• www.ncepod.org.uk
• www.nice.org.uk
• www.renal.org/pages/pages/guidelines/current/arf.php
• www.asn-online.org
• www.aintreerenalunit.nhs.uk