STOP AKI in Malawi

London Acute Kidney Injury Network

AKI in Trauma and Surgery (Rhabdomyolysis)

Chris Kirwan

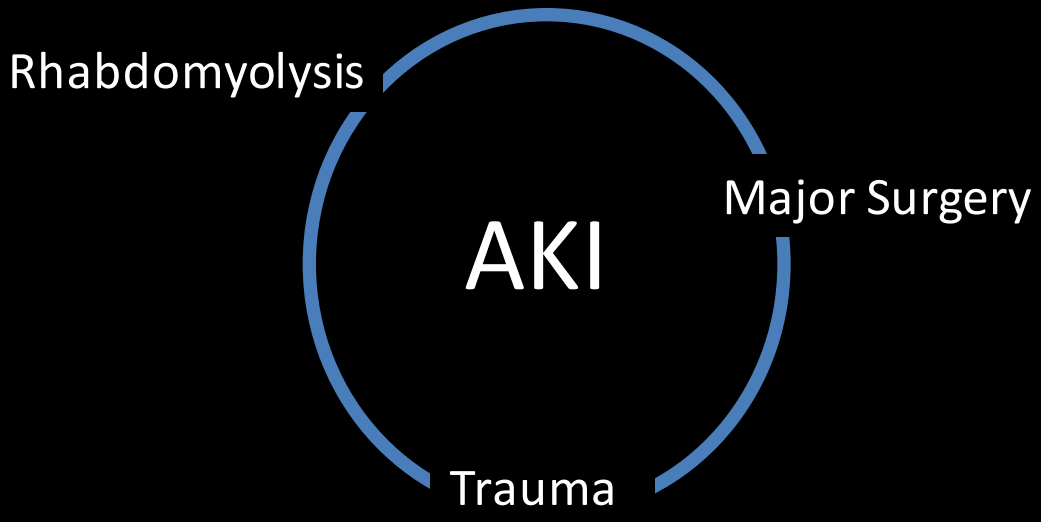
Consultant in Critical Care and Renal Medicine

Royal London Hospital

Barts Health NHS

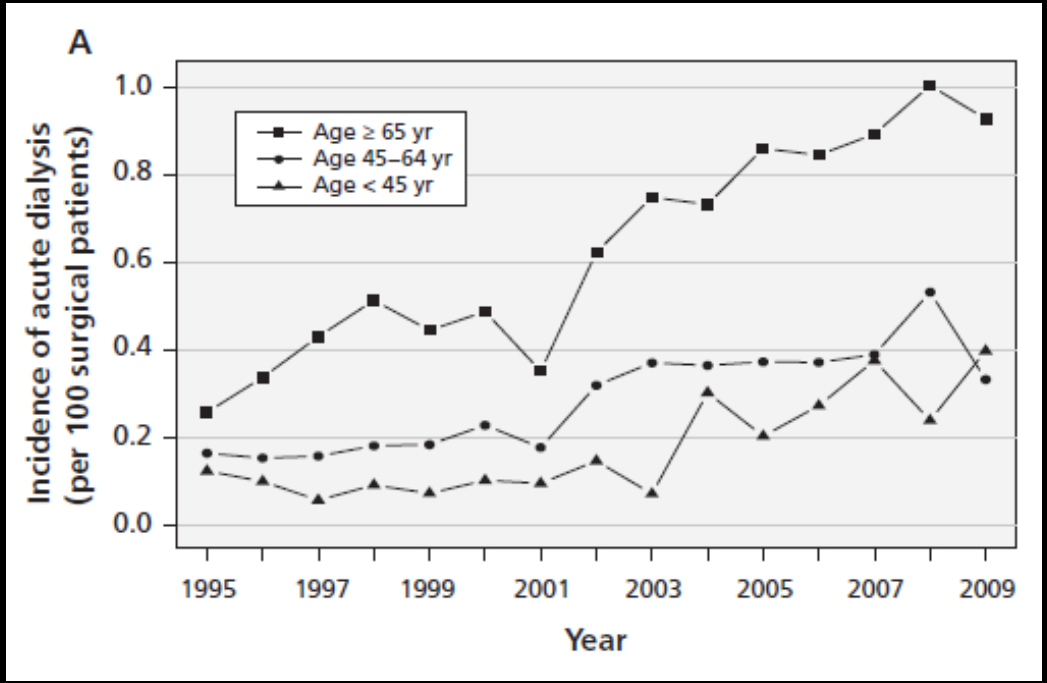
NHS Trust

Overview



Major Surgery

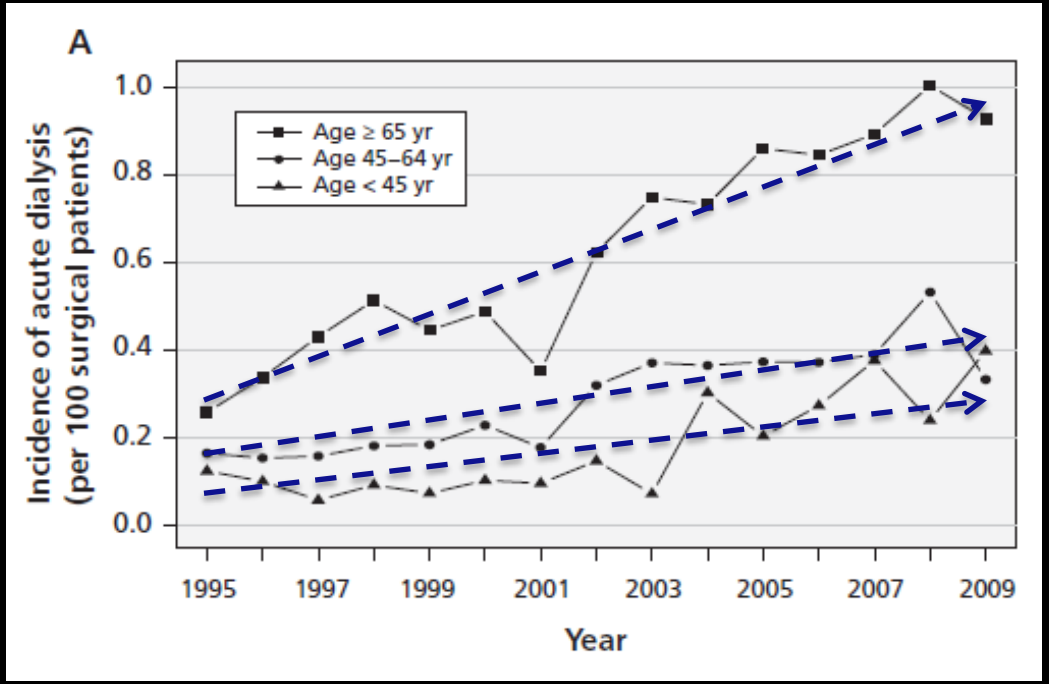
- Surgery and AKI
  - The need for acute dialysis is increasing in all age groups following major surgery[1]



[1]Siddiqui CMAJ 2012

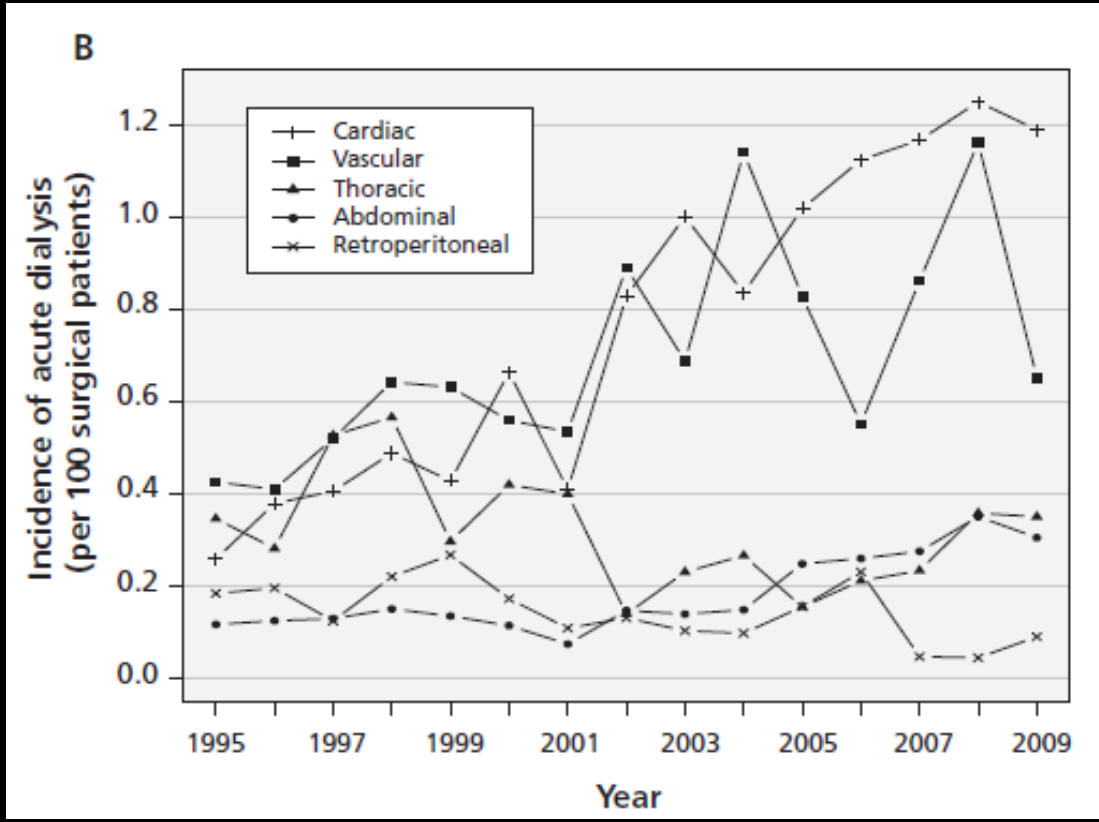
Major Surgery

- Surgery and AKI
  - The need for acute dialysis is increasing in all age groups following major surgery[1]



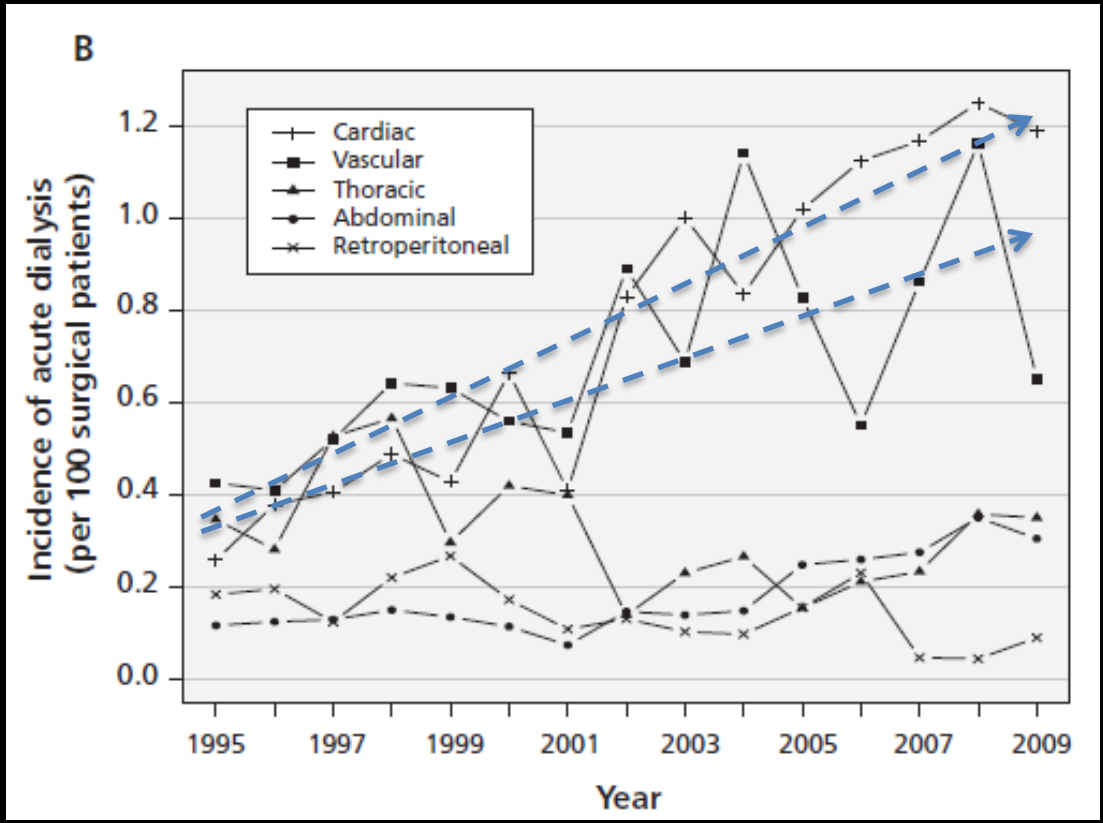
[1]Siddiqui CMAJ 2012

Specific Types of Surgery



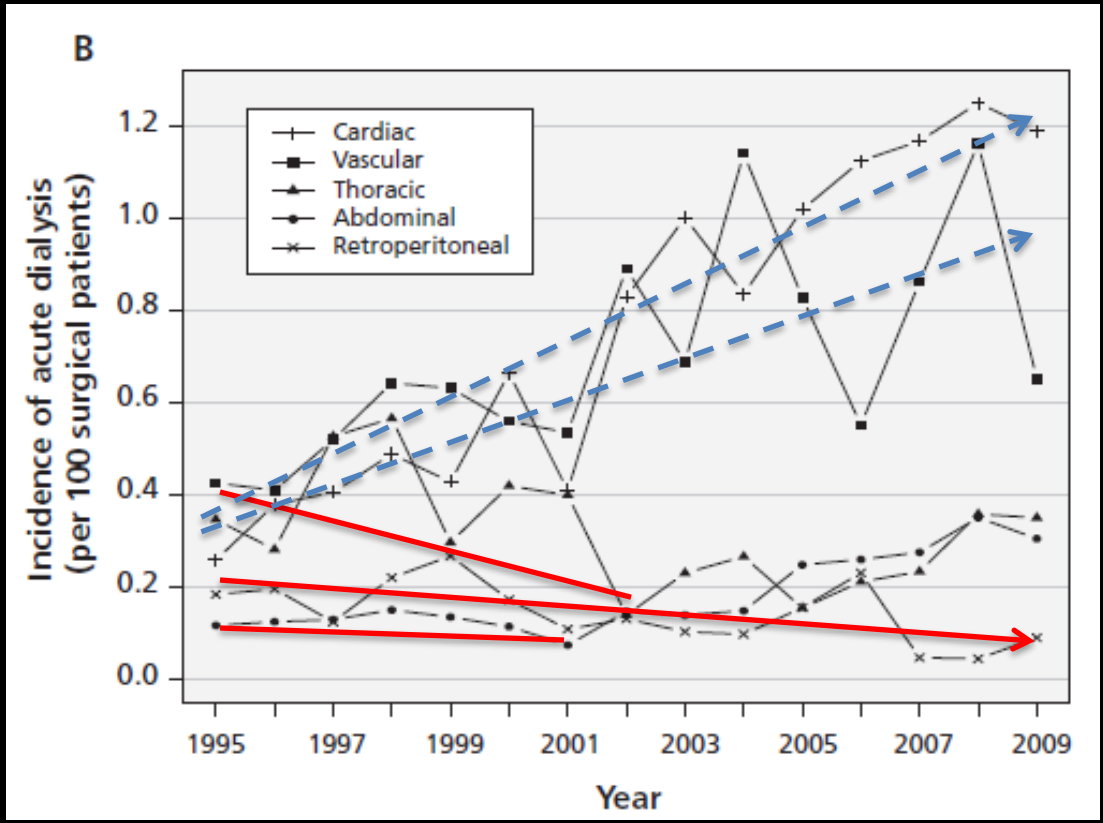
[1]Siddiqui CMAJ 2012

Specific Types of Surgery



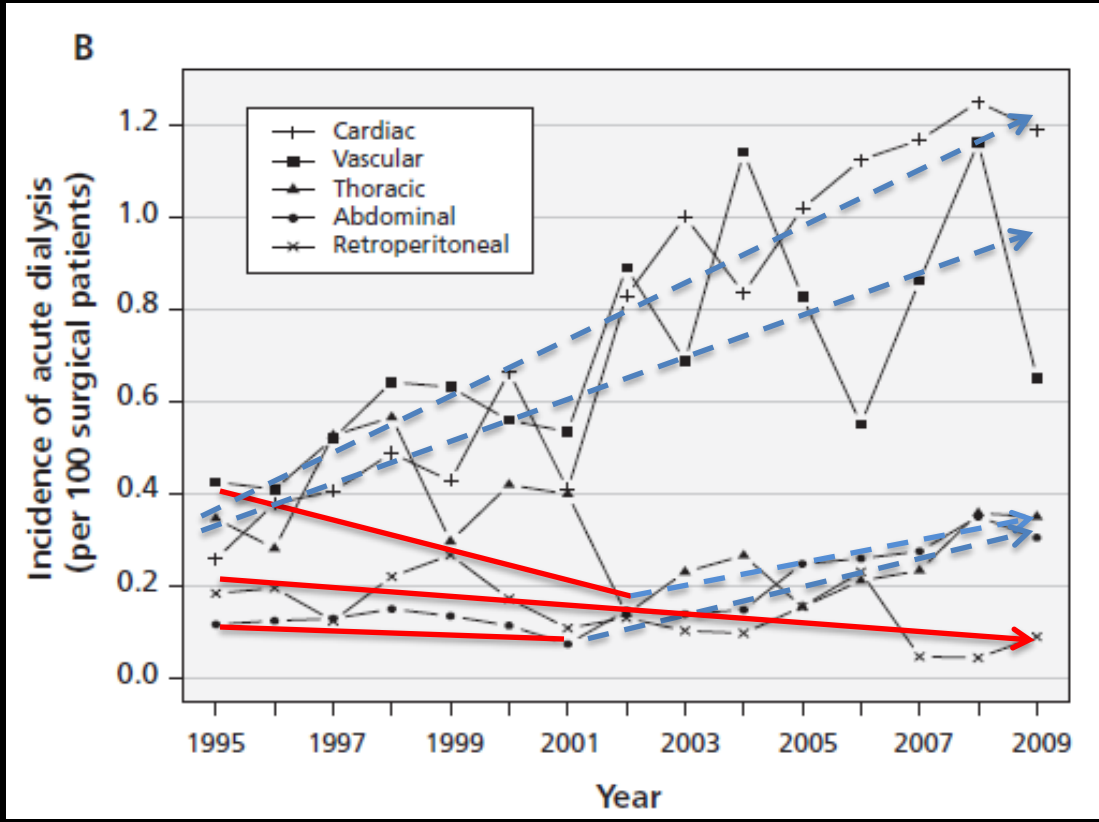
[1]Siddiqui CMAJ 2012

Specific Types of Surgery



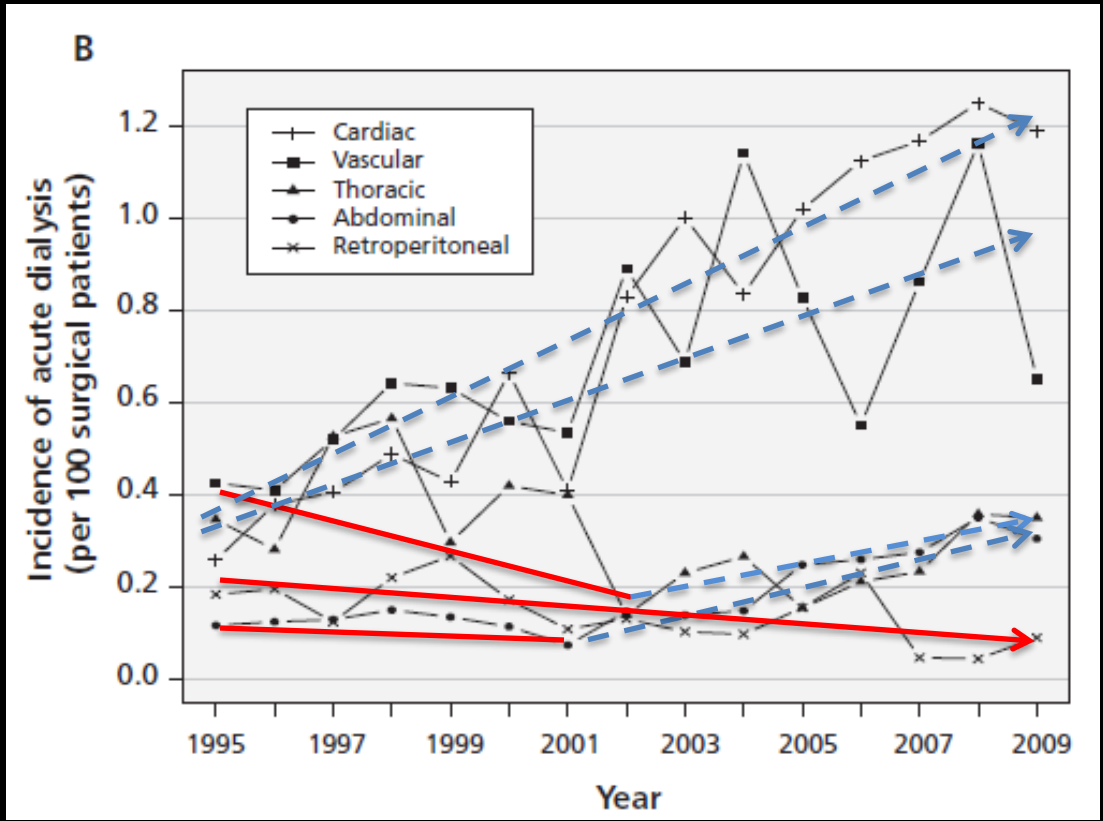
[1]Siddiqui CMAJ 2012

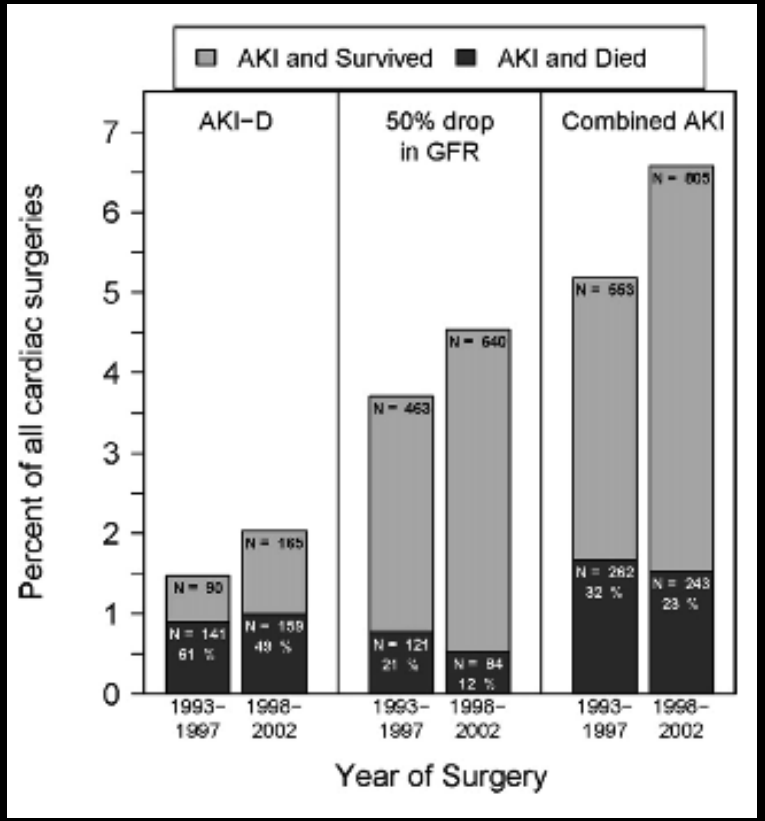
Specific Types of Surgery



[1]Siddiqui CMAJ 2012

Specific Types of Surgery





[1]Siddiqui CMAJ 2012

[2]Thakar AJKD 2007

Preventing AKI after Surgery

- LAKIN

  - Internet
  - App

www.londonaki.net

- Peri-operative guidelines for management of AKI

London Acute Kidney Injury Network


AKI
Find out more about acute kidney injury


Network
Learn about us and our objectives

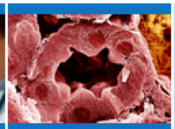

Clinical
Guidelines, pathways and toolkit


Academy
Educational resources and events


Audit
Learn about our audit projects and results


Research
Acute kidney injury research projects


Patients
Support for AKI patients and families


News
Find out about the latest developments

Clinical

- Toolkit
- Guidelines and pathways
- Recognition
- Links
- Contacts

Guidelines and pathways

These guidelines are on 'core' AKI prevention and management with key patient pathways described. We are, in addition, developing guidelines and pathways for more specialised areas of AKI care (such as pregancy and AKI secondary to liver disease).

Guidelines and pathways may be accessed via the links below. Alternatively download the AKI manual PDF.

- Risk, prevention, recognition (PDF)
- AKI care bundle (PDF)
- AKI care bundle checklist (PDF)
- STOP AKI & checklist (PDF)
- AKI complications (PDF)
- Referral from Ward (PDF)
- Referral from Ward to Kidney Unit Checklist (PDF)
- Transfer from Ward to Kidney Unit (PDF)
- Transfer from Ward to Kidney Unit Checklist (PDF)
- Referral from Critical Care to Nephrology (PDF)
- Transfer from Critical Care to Kidney Unit (PDF)
- Referral from Primary Care
- Contrast Induced Nephropathy Prophylaxis(PDF)
- Perioperative AKI (PDF)
- Fluids (PDF)
- AKI Teaching materials (PDF)
- Kidney Unit Contacts
- Recognition
- Clinical links

Downloads


Download the London AKI manual (PDF)

Preventing AKI after Surgery

- LAKIN

  - Internet
  - App

www.londonaki.net

- Peri-operative guidelines for management of AKI

Does perioperative hemodynamic optimization protect renal function in surgical patients? A meta-analytic study

Nicola Brienza, MD, PhD; Maria Teresa Giglio, MD; Massimo Marucci, MD; Tommaso Fiore, MD

Crit Care Med 2009 Vol. 37, No. 6

Preventing AKI after Surgery

- LAKIN

  – Internet

  – App

www.londonaki.net

- Peri-operative guidelines for management of AKI

Does perioperative hemodynamic optimization protect renal function in surgical patients? A meta-analytic study

Nicola Brienza, MD, PhD; Maria Teresa Giglio, MD; Massimo Marucci, MD; Tommaso Fiore, MD

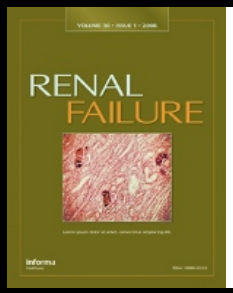
Crit Care Med 2009 Vol. 37, No. 6

YES!

Trauma

Confusing literature

- Bagshaw S. *A multi center evaluation of early AKI in critically ill trauma patents.* Renal Failure 2008
- Yuan F. *Natural history and impact of AKI in patients who have had an RTA.* Clinical Nephrology 2009
- Livia K. *AKI after Trauma.* Indian J CCM 2010
- Gomes E. *AKI in severe trauma*. Scandinavian J TREM 2010



A Multi-Center Evaluation of Early Acute Kidney Injury in Critically Ill Trauma Patients

2008, Vol. 30, No. 6 , Pages 581-589

Sean M. Bagshaw[1†], Carol George[2], R.T. Noel Gibney[1] and Rinaldo Bellomo[3]

- 9449 critically ill trauma patients
- AKI 18.1%
- Mortality 16.7% v 7.8%
  - Older
  - Female OR 1.6
  - Co-morbidities OR 2.7
- AKI as independent risk of mortality
  - Risk OR 1.68
  - Injury OR 1.88
  - Failure OR 2.29

Clin Nephrol. 2009 Jun;71(6):669-79.

Natural history and impact on outcomes of acute kidney injury in patients with road traffic injury.

Yuan F, Hou FF, Wu Q, Chen PY, Xie D, Zhang X.

1Division of Nephrology, Nanfang Hospital, and 2Department of Biostatistics, Southern Medical University, Guangzhou, P.R. China.

- 3945 patients who had been in an RTA in Guangzhou, China
- AKI in 423 (10.7%)
  - RRT in 59 (13.9%)
- Vasopressors and high does loop diuretics were risk factors for AKI
- Mortality
  - No AKI 7.1%
  - Risk 37.4%
  - Injury 52.9%
  - Failure 79.2%
- 77.5% of AKI survivors had ‘normal’ renal function on d/c
  - No long term f/u

Research Article

IJCCM Indian Journal of Critical Care Medicine
Official Publication of Indian Society of Critical Care Medicine

Acute kidney injury after trauma: Prevalence, clinical characteristics and RIFLE classification

Krasnalhia Lívia S. de Abreu[1], Geraldo B. Silva Júnior[1], Adller G. C. Barreto[1], Fernanda M. Melo[1], Bárbara B. Oliveira[1], Rosa M. S. Mota[2], Natália A. Rocha[1], Sônia L. Silva[1,3], Sônia M. H. A. Araújo[1], Elizabeth F. Daher[1]

Brazil

- 129 patients – 80% male – mean age: 32m / 22w
- 55 AKI
  - More Abdominal trauma
  - Less brain trauma
  - 19 RRT
  - Longer ICU and hospital stay
  - 50 had rhabdomyolysis
- Mortality was 95.3% for all trauma patients!

Gomes et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine 2010, 18:1
http://www.sjtrem.com/content/18/1/1

SCANDINAVIAN JOURNAL OF trauma, resuscitation & emergency medicine

ORIGINAL RESEARCH Open Access

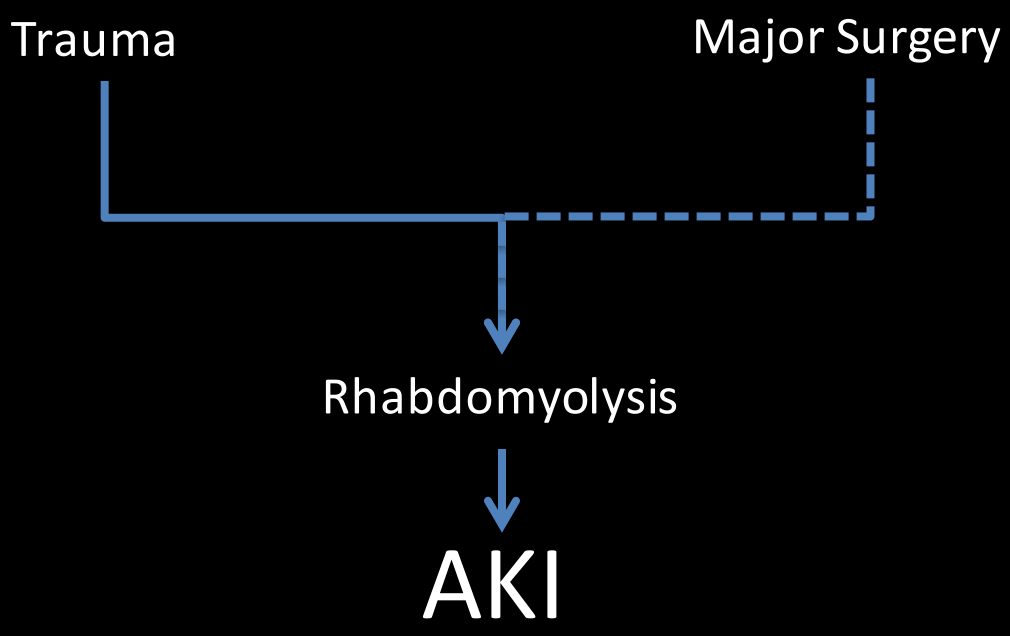
Acute kidney injury in severe trauma assessed by RIFLE criteria: a common feature without implications on mortality?

Ernestina Gomes[1], Rui Antunes[1*], Cláudia Dias[2], Rui Araújo[1], Altamiro Costa-Pereira[3]

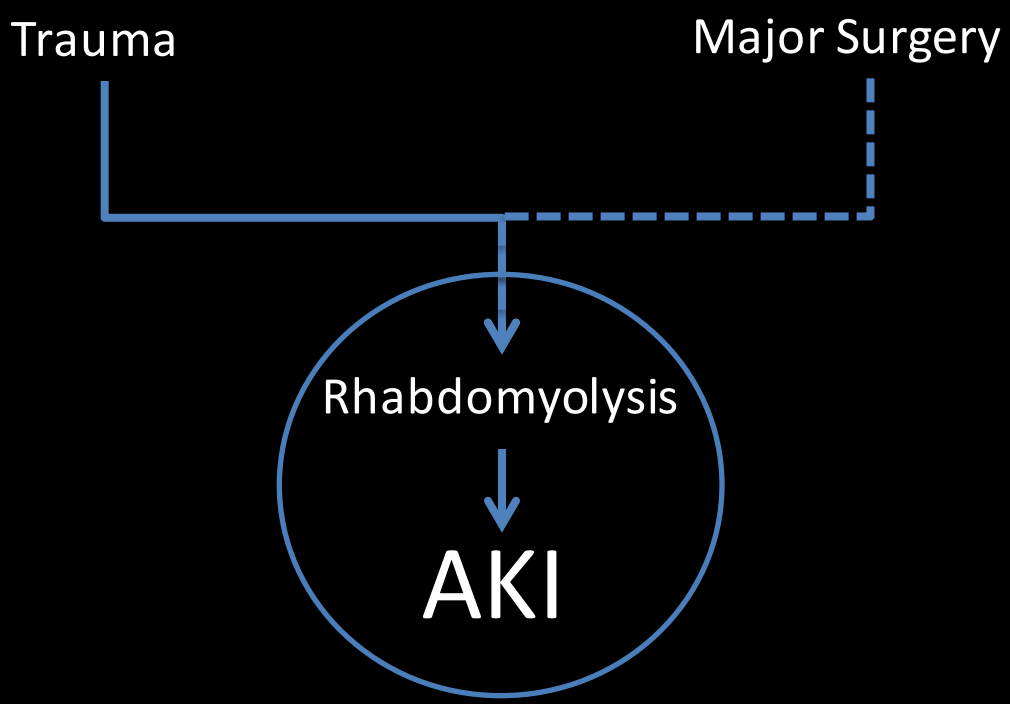
Portugal

- 436 patients – 80% male – median age 37
- AKI : no AKI was a 50:50 split
  - None underwent RRT
  - Mortality ~20% in all groups
- AKI
  - Longer ICU stay (significantly so if AKI 3)
  - Longer stay in hospital
  - Lower early mortality (<2days)
    - Probably due to increase in severe head injury in no AKI group

AKI in Rhabdomyolysis



AKI in Rhabdomyolysis



London
1940 – 1941

Daily Mail

SHERLEY'S

LATE WAR NEWS SPECIAL

Bluemel's

WAR'S GREATEST PICTURE: St. Paul's Stands Unharmed in the Midst of the Burning City

Hitler Planned Monday Swoop

London was to Blaze First

America Moves

LATEST

LONDON LULLABY

100 to 1 Backing for Roosevelt

HAVOC COULD HAVE BEEN SAVED

Berlin Radio Went 'All Quiet'

China Seeks U.S. Planes

London
1940 – 1941

Prof. Eric Bywaters
(1910-2003)

Hammersmith Hospital

Case Report

- Patient had been buried for several hours
- On admission …. he looks good apart from swelling of the limb
- His blood pressure falls
- Signs of renal damage soon appear
- The urine contains albumin and dark brown granular casts

BRITISH MEDICAL JOURNAL

LONDON SATURDAY MARCH 22 1941

CRUSH INJURIES WITH IMPAIRMENT OF RENAL FUNCTION

BY

E. G. L. BYWATERS, M.B., B.S., M.R.C.P.

Beit Memorial Fellow

AND

D. BEALL, Ph.D.Toronto

(From the Departments of Medicine and Pathology, British Postgraduate Medical School)

[WITH SPECIAL PLATE]

Amongst air-raid casualties seen at this hospital have been four cases of crush injury of the limbs which, because of the general similarity of their clinical course, were thought to represent a specific and hitherto unreported syndrome, and one which has been and will be seen elsewhere during the war. Such a condition may have been observed in civil practice, but we have been unable to find any account of it in the literature. The cases are of interest on account of the problem propounded by both pathogenesis and treatment. The picture presented by these four cases, and substantiated by others, is briefly as follows:

The patient has been buried for several hours with pressure on a limb. On admission he looks in good condition except for swelling of the limb, some local anaesthesia, and wheals. The haemoglobin, however, is raised, and a few hours later, despite vasoconstriction, made manifest by pallor, coldness, and sweating, the blood pressure falls. This is restored to pre-shock level by (often multiple) transfusions of serum, plasma, or, occasionally, blood. Anxiety may now arise concerning the circulation in the injured limb, which may show diminution of arterial pulsation distally, accompanied by all the changes of incipient gangrene. Signs of renal damage soon appear, and progress even though the crushed limb be amputated. The urinary output, initially small, owing perhaps to the severity of the shock, diminishes further. The urine contains albumin and many dark brown or black granular casts. These later decrease in number. The patient is alternately drowsy and anxiously aware of the severity of his illness. Slight generalized oedema, thirst, and incessant vomiting develop, and the blood pressure often remains slightly raised. The blood urea and potassium, raised at an early stage, become progressively higher, and death occurs comparatively suddenly, frequently within a week. Necropsy reveals necrosis of muscle and, in the renal tubules, degenerative changes and casts containing brown pigment.

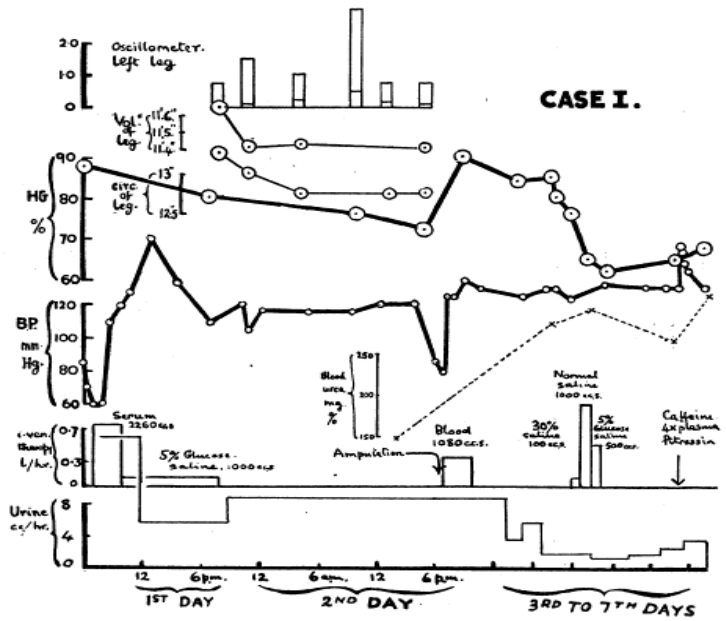


CHART I.—Case I.

Case I

A female aged 17 had been buried for nine hours with heavy masonry lying across the left leg. On admission she showed slight bruises generally, and multiple superficial abrasions below the left knee. The leg was swollen and sensation was impaired at the ankle, where all power and movement were lost. Other limbs appeared undamaged. The skin was pallid and clammy; the blood pressure was 85/70 mm. Hg. The clinical course is shown on Chart I. Recalcified plasma–saline (Clegg and Dible, 1940) (subsequently referred to as "serum"), followed by 5% glucose–saline,

Brief Pathophysiology of Rhabdomyolysis

- Rhabdomyolysis – ‘the dissolution of striped (skeletal) muscle’
  - Release of muscle cell contents
    - Myoglobin
    - The surrogate marker we measure most commonly is CPK

Myoglobin and AKI

- Myoglobin
  - Iron and O_2 binding protein
  - 17.8 kDa
  - Freely filtered at the glomerulus
  - Tubular epithelial cells metabolise it
  - Appears in urine when concentration is >0.5-1.5mg/dL
  - Urine becomes red when concentration is >100mg/dL
  - Myoglobinuria only occurs in the context of rhabdomyolysis

Myoglobin and AKI

- The toxic effects of myoglobin……
  - Intra renal vasoconstriction
    - Tx A2
    - Endothelin 1
    - TNFα

- Hypovolaemia
- RAS

  - Direct and ischaemic tubular injury
    - Heme
    - Free radicals
      - » Fe^{3+}
  - Tubular obstruction
    - Tamm-Horsfall protein
    - Acidic urine

The basics of rhabdomyolysis

Bosch et al NEJM 2009

- Its common
- It is bad for you as a consequence of severe illness
- There are many many causes and often its multifactorial
- AKI often recovers if it’s a simple course

Treatment of AKI caused by Rhabdomyolysis

- Cause*
  - Fasciotomy (Trauma)
- Fluids
  - Early
  - Diuretics
- Alkalisation of the urine
  - Bicarbonate
- Extracorporeal removal of myoglobin
  - High volume HF
  - Super high flux HD

Fluid Therapy

- Where is the best place to find data……

Fluid Therapy

- Where is the best place to find data……

J Am Soc Nephrol 15: 1862–1867, 2004

Early and Vigorous Fluid Resuscitation Prevents Acute Renal Failure in the Crush Victims of Catastrophic Earthquakes

The American Journal of Emergency Medicine

Prophylactic fluid therapy in crushed victims of Bam earthquake ☆

Najafi Iraj [a b], Safari Saeed [a,b,c,*], Hosseini Mostafa [d], Sanadgol Houshang [e], Sharifi Ali [b], Rashid Farokhi Farin [f], Seirafian Shiva [g], Mooraki Ahmad [h], Hamidreza Samimagham [i], Vahid Pourfarziani [j], Atabak Shahnaz [k], Osareh Shahrzad [l], Boroumand Behrooz [h]

Fluid Therapy

A brief summary of the main messages from both papers

- Worse the injury / time spent under rubble, the worse the AKI ($p<0.05$)
- The earlier fluids are given (i.e. on scene) the better the outcome ($p<0.001$)

- The more fluids per day given the better the outcome ($p<0.005$)
  - 6L in severe (CK>15,000)
  - 3L in moderate (CK >5000)
- Alkalisation of the urine
  - Alkaline Mannitol diuresis

Fluid Therapy

A brief summary of the main messages from both papers

- Worse the injury / time spent under rubble, the worse the AKI ($p<0.05$)
- The earlier fluids are given (i.e. on scene) the better the outcome ($p<0.001$) – (debatable, but within 24 hours is a must)
- The more fluids per day given the better the outcome ($p<0.005$)
  - 6L in severe (CK>15,000)
  - 3L in moderate (CK >5000)
- Alkalisation of the urine
  - Alkaline Mannitol diuresis (resource issue)

- Other literature suggests 12 to 24L of fluid in a day but <3L in a day causes an upsurge in the cases of AKI

Beware early high volume fluids in haemorrhagic trauma

Extracorporeal Myoglobin Removal

- High volume HF[1] with a large Filter (1.9m^2)
  - Pore size ~50kDa
  - Blood flows >300mL/min and high exchange rate
  - Efficiency
    - 300ml/min blood and 60mL / 70kg patient / hr (4.2L exchange)
      - i.e. ~70mL/min exchange ~23% clearance
- High Flux / Super High Flux Haemodialysis[2]
  - Pore size 30-60kDa (conventional HD <15kDa)
  - Efficiency
    - High flux dialysis ~50% clearance

[1]Ling et al J of Injury 2010, Naka et al Critical Care 2005
[2]Basnayake et al NEJM 2009 (letter)

RLH experience

RLH experience

Level 1 Trauma Centre

1500 ICU admissions a year

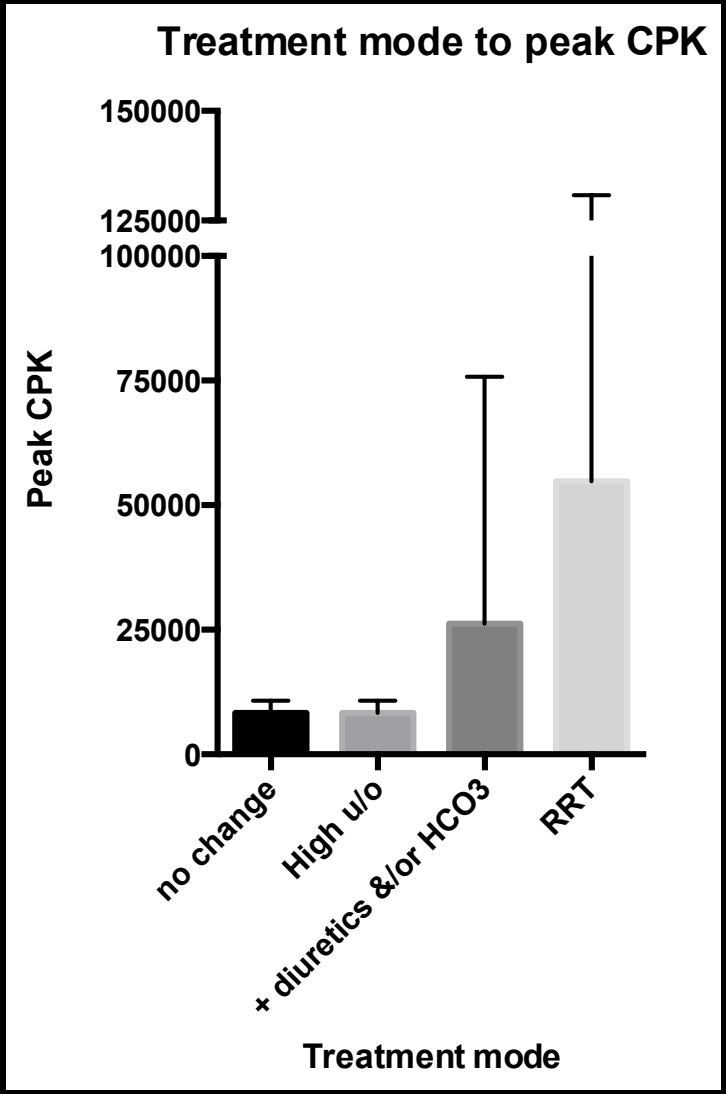
- ~ 25% of our ICU admissions have trauma as primary diagnosis
- 71 patients with a CPK > 5000 IU/L (1st July 2012 – 1st January 2013)
  - ~20% of trauma admissions
- Male 54 (76%)
- Median age 41 (16-88)
- 23 died (32%)
- 36 patients had CPK > 5000 IU/L for >3 days

RLH experience

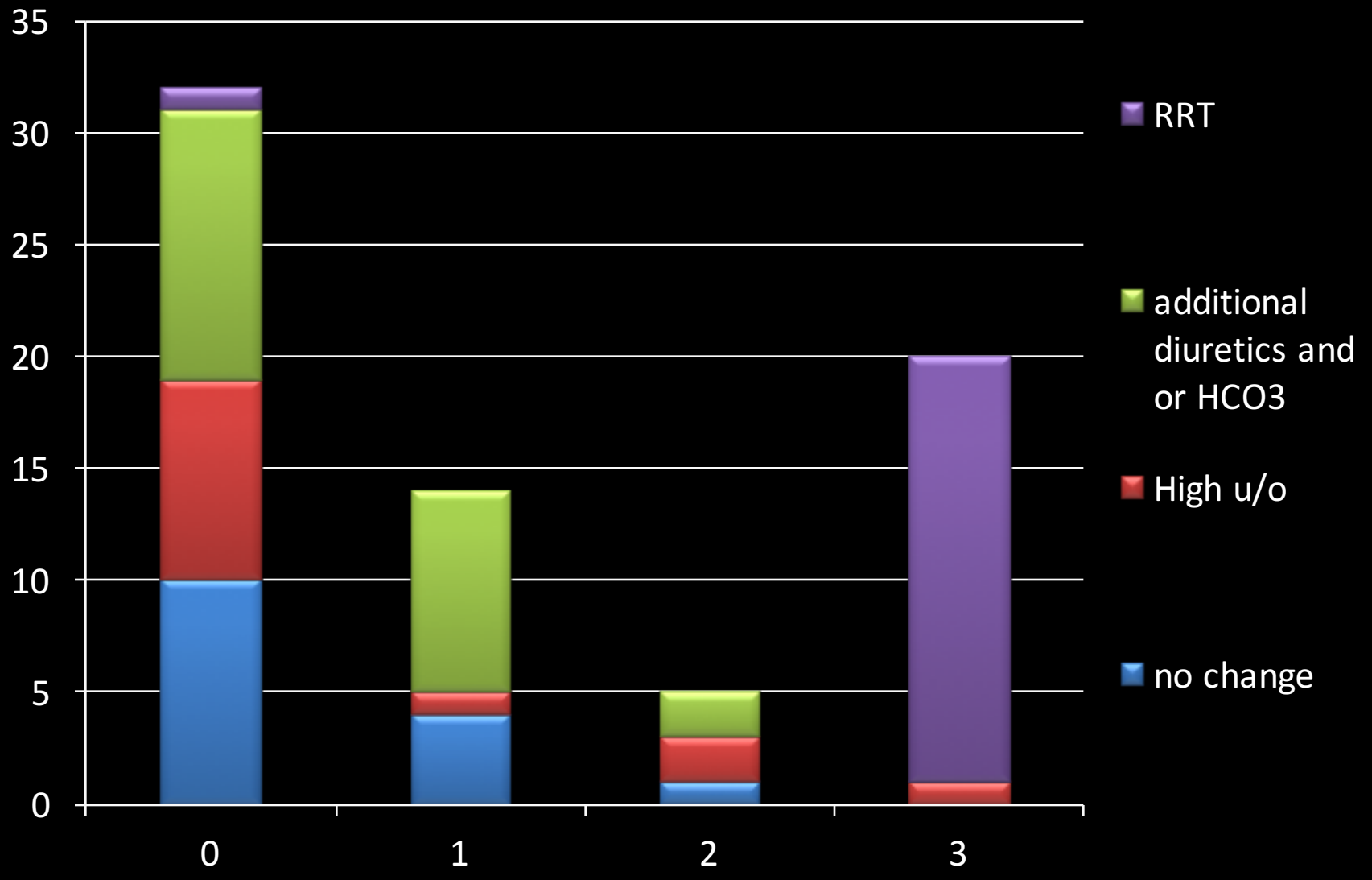
- Causes of elevated CPK
  - Polytrauma (59%)
  - Sepsis (17%)
  - Metabolic (14%)
  - Ischaemia (10%)
    - However; in patients requiring RRT, polytrauma was only 49%

RLH experience

- Treatment
  - No set unit policy
  - 24 high in / out fluid strategy alone – >2mL/kg/hour urine
    - 12 received furosemide
  - 11 high in / out fluid strategy and additional bicarbonate
    - 8 received furosemide
  - *Not all achieved high out / high in despite therapy*
  - 19 high volume CVVHF
    - 15 died
  - 15 no alteration to routine ICU management



Treatment mode and AKI status



RLH experience

- 39 (55%) patients developed AKI
  - 19 (27%) required RRT

	No AKI (n=32)	AKI 1-3 no RRT (n=20)	RRT (n=19)
Age (Median, Range)	35 (16-69)	50 (17-88)	53 (24-85)
Male Sex	81%	70%	74%
Trauma	63%	70%	42%
Medical	31%	10%	32%
Surgical	6%	20%	26%
APACHE 2 score (Median, Range)	10 (6-30)	11 (7-17)	17 (10-34)
Peak CK (IU/L) (Median, Range)	10606 (5016-212200)	7845 (5055-150000)	45851 (5003-344300)
iv Fluid (ml) in 24h after CK>5000 (Median, Range)	1770 (0-7987)	2444 (0-7927)	2767 (750-11000)
Hospital Mortality	9%	25%	79%

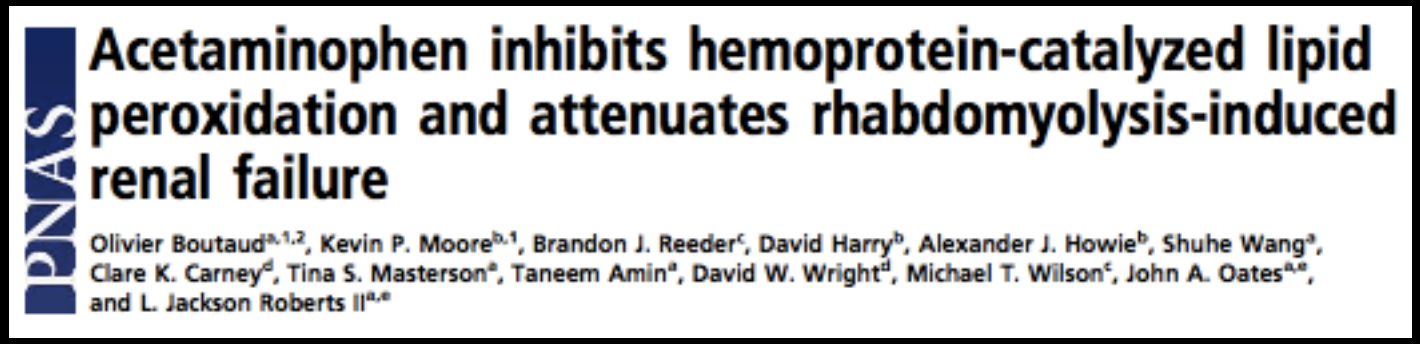
[Patinets with CK>5000 in ICU]

RLH experience

- RRT
  - Strongly associated with risk of death (79% v 15%, p<0.0001)
  - Only 10 received high volume / dose RRT (>60mL/kg/hr)
    - Commenced: median day 2 (1-3) of ICU stay
      - 6 on the first day
    - 4 within 48 hours of CK>5000
    - 9 died
  - In the 9 who received conventional dose
    - Commenced: median day 5 (2-13)
      - 7 had RRT timing unrelated to CK level
    - 6 died

Prevention of AKI caused by rhabdomyolysis – translational research

Prevention of AKI caused by rhabdomyolysis – translational research



PNAS

Acetaminophen inhibits hemoprotein-catalyzed lipid peroxidation and attenuates rhabdomyolysis-induced renal failure

Olivier Boutaud[a,1,2], Kevin P. Moore[b,1], Brandon J. Reeder[c], David Harry[b], Alexander J. Howie[b], Shuhe Wang[a], Clare K. Carney[d], Tina S. Masterson[a], Taneem Amin[a], David W. Wright[d], Michael T. Wilson[c], John A. Oates[a,e], and L. Jackson Roberts II[a,e]

2010

Prevention of AKI caused by rhabdomyolysis – translational research

PNAS

Acetaminophen inhibits hemoprotein-catalyzed lipid peroxidation and attenuates rhabdomyolysis-induced renal failure

Olivier Boutaud[a,1,2], Kevin P. Moore[b,1], Brandon J. Reeder[c], David Harry[b], Alexander J. Howie[b], Shuhe Wang[a], Clare K. Carney[d], Tina S. Masterson[a], Taneem Amin[a], David W. Wright[d], Michael T. Wilson[c], John A. Oates[a,e], and L. Jackson Roberts II[a,e]

2010

Acetaminophen induced Rhabdomyolysis

Allergy (54) 1999; 1115

Moneret-Vautrin et al

Alternative Prevention Strategies?

BRITISH MEDICAL JOURNAL

LONDON SATURDAY MARCH 22 1941

CRUSH INJURIES WITH IMPAIRMENT OF RENAL FUNCTION

BY

E. G. L. BYWATERS, M.B., B.S., M.R.C.P.

Beit Memorial Fellow

AND

D. BEALL, Ph.D.Toronto

(From the Departments of Medicine and Pathology, British Postgraduate Medical School)

Finally, one patient whom I saw through the kindness of Dr. Grant, whose patient he was, had drunk four pints of beer just before the establishment was demolished. They dug him out 11 hours later with both legs broken. In spite of a fairly high blood potassium level he recovered, but showed little haemoconcentration or uraemia. The possible protective action of this beverage might be worth investigating.

Treatment

The natural tendency under emergency conditions is to treat shock first, then the local limb condition, and lastly the renal failure on or about the third or fourth day, when signs of renal damage are obvious. Since it is possible that the renal damage occurs soon after the re-establishment of an adequate

Alternative Prevention Strategies?

BRITISH MEDICAL JOURNAL

LONDON SATURDAY MARCH 22 1941

CRUSH INJURIES WITH IMPAIRMENT OF RENAL FUNCTION

BY

E. G. L. BYWATERS, M.B., B.S., M.R.C.P.

Beit Memorial Fellow

AND

D. BEALL, Ph.D.Toronto

(From the Departments of Medicine and Pathology, British Postgraduate Medical School)

Finally, one patient whom I saw through the kindness of Dr. Grant, whose patient he was, had drunk four pints of beer just before the establishment was demolished. They dug him out 11 hours later with both legs broken. In spite of a fairly high blood potassium level he recovered, but showed little haemoconcentration or uraemia. The possible protective action of this beverage might be worth investigating.

Treatment

The natural tendency under emergency conditions is to treat shock first, then the local limb condition, and lastly the renal failure on or about the third or fourth day, when signs of renal damage are obvious. Since it is possible that the renal damage occurs soon after the re-establishment of an adequate

Conclusions

- AKI is common following major surgery
  - There are simple measures and easily available guidance to help prevent this throughout the peri-operative period
- AKI is common following major trauma
  - These are a different epidemiological group to routine AKI patients
    - » though the risk factors remain the same
  - AKI has an impact on mortality

Conclusions

- Severe AKI following rhabdomyolysis is rare
  - Early fluid resuscitation
    - high out / high in and keep the urine pH>6
  - Can consider renal replacement therapy for myoglobin removal
    - The need for RRT is associated with a poor outcome
  - Should we give paracetamol early?

Acknowledgements

- Nirmala Chakkalakal — SpR ICM
- Rachelle Taylor — ICNARC Auditor
- John Prowle — Consultant in Critical Care / Nephrology
- Mike Almond — Consultant Nephrologist