Green Dialysis

PART II

LET’S SEE WHAT WE HAVE BEEN UP TO IN MY TOWN

Prof John Agar
Renal Services, University Hospital Geelong
Barwon Health, Geelong, Australia

ADC – Seattle: February 28th 2016
Geelong - Australia
Geelong - Australia

- A city of 250,000
- The second city to Melbourne in the state of Victoria
- A medium-sized Australian Renal Service
- 177 dialysis patients
  - 105 facility-based haemodialysis patients
  - 47 home haemodialysis patients
  - 25 home peritoneal dialysis patients
  - 41% @ home
In 2000 we began an aggressive push to establish home nocturnal dialysis in Australia.

But, sometimes unintended consequences occur.
Our focus on the eco-impact of HD arose from an unintended consequence of our home nocturnal HD program
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At the start, we did not appreciate that the costs of water, power and waste disposal ... usually paid by the facility ... would now be borne by the patient
Problem 1
Geelong is drought-prone

Problem 2
Our home patients were happy and well but were getting poorer
Problem 1
Geelong is drought-prone

Problem 2
Our home patients were happy and well but were getting poorer

We had failed to anticipate the inadvertent transfer of all utility costs from the institution to the patient
To begin ... and this is of critical importance

It **always** shocks me how many get this wrong
To begin ... and this is of critical importance

It always shocks me how many get this wrong.
RO reject water is not patient-contact water.
To begin ... and this is of critical importance

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RO reject water is **not** patient-contact water
To begin ... and this is of critical importance

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RO reject water is **not** patient-contact water
It is not intended you read the next table

but

it **does** show that RO reject water is **potable** water
<table>
<thead>
<tr>
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<td>Total Hardnes</td>
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My pitch to my Hospital Board
(2003)

Glass A
Supermarket mineral water

Glass B
Direct sample: RO reject pipe
My pitch to my Hospital Board
(2003)

Glass A
Supermarket mineral water

Glass B
Direct sample: RO reject pipe

which
is
which
Re-using RO reject water

- **In-centre** = constant water re-use
  - CSSD – water for sterilising systems
  - Ward toilet flushing
  - BH landscape maintenance

- **Satellites** = variable water re-use
  - Rehabilitation/High-level Care landscape use
  - Sports/Schools organisations

- **Home** = several re-use options
  - Household, garden, livestock, or other uses
Re-using RO reject water

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• **Home = several re-use options**
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Our home systems
(Household reuse)

Unsophisticated
but .. they work
Not all conservation imperatives are suited to - or apply to - all regions

Some regions have lots of water
others don’t

Some regions have lots of sun
other don’t
Water conservation matters more for some
Water conservation matters more for some than for others.
Some places could apply solar power
Some places could apply solar power more than others.
But waste?
Well ... waste is an issue for everyone
and ...
we can do better
Re-using reject water allows ~100,000 L per week to be re-used across the BH health service
Bringing it home to the US ...
Think on this ...

• In 2012, 32,796\textsuperscript{(2012: USRDS)} Californians were on dialysis

• Assume that all
  – had 3 sessions of dialysis a week
  – used a \( Q_d \) of 500 mL/minute
  – used city or town mains water
  – processed that water by reverse osmosis (RO)
  – with an RO with a “reject rate” of 60%
  – and had treatment times equal to the US mean of 211 min

Table B.8.1 in the USRDS 2014 ADR
Then ...

Unless that RO reject water is re-used ...

• and ... remember ...
Max. Limits  +  Mains vs. Post-RO data - 2 sites (Geelong, Australia)  +  EPA Standards

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Unless that RO reject water is re-used, then, each year in California ...

- 32,796 (patients)
- x 211 (minutes)
- x 0.75 L (potable RO reject discarded/minute)
- x 3 (treatments/week)
- x 52 (weeks/year)

= 809,634,852 litres/year

= 213,882,900 US gallons/year

is needlessly being discarded
As a standard Olympic pool holds \( 2.5 \times 10^6 \) L

and in the midst of a drought
Californian dialysis services are
thoughtlessly annually discarding
enough potable water to fill \( \sim325 \) pools.
As a standard Olympic pool holds $2.5 \times 10^6$ L and in the midst of a drought Californian dialysis services are thoughtlessly annually discarding enough potable water to fill ~325 pools.

At a standard length of 50m the end-on-end stretch of ‘discarded’ Olympic pools would thus be 16.5 km long

= ~10.25 US miles.
As a standard Olympic pool holds $2.5 \times 10^6$ L

and in the midst of a drought
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$= \sim 10.25$ US miles.

ERRATUM
I blogged a wrong value in 2015 at HDC’s KidneyViews
based on an erroneous number for Californians on dialysis
And
With approaching 500,000 Americans on dialysis for the US as a whole

Potable water discarded
= 12,343,500,000 L

Pools end on end
= 4937

US miles of Olympic Pool
= 77.5 miles
What about power?
What about power?

this ...
or this ...

this ...
Geelong Home Dialysis Program

- **Home Training Unit**
  - 4 station unit x ~3 mean patients/day x 5 days/week
  - 18 panels all power for 4 x machines + 4 x mini-RO’s

Agar JWM. HDI. 2011. 15(1): 142-143
Geelong Home Dialysis Program

• Home Training Unit
  - 4 station unit x ~3 mean patients/day x 5 days/week
  - 18 panels all power for 4 x machines + 4 x mini-RO’s

• Home
  - 3 x systems installed
  - All dialysis power + household power
  - Evaluation ongoing but information to date = effective power-bill = $0

= on-going use and evaluation

Agar JWM. HDI. 2011. 15(1): 142-143
The future ... the new Tesla battery

- New, mega-storage lithium-ion batteries (eg: the Tesla battery) are now emerging that will:
  - run home + electric cars
  - bank renewable energy to allow on-demand solar and wind power
  - after sunset
  - when the wind dies down
  - or ... for home overnight HD

Then there is waste ...
= 2.9 kg per $R_x$

= 450 kg/yr [centre x 3/wk]
or 750 kg/yr [home x 5/wk]
... most dialysis waste in 2015?

Landfill
... most dialysis waste in 2015?

Landfill

Incineration
On-site sterilisation and shredding
Waste disposal

• While we are yet to install on-site waste-disposal ... (no $’s)
• A SteriMed system is now performing well in Alice Springs*
• Several operating systems now permit:
  o On-site autoclave + sterilize + shred of ALL post-dialysis waste ... ALL!
  o The sterile ‘shreddate’ can then be potentially be recycled for re-use

* Personal Communication: Fresenius Medical Care (Aust.)
Multi-potential re-use of shreddedate

- The shreddedate is sterile
- No infectious waste issues with disposal
- But, also consider ...
  - On-sale to plastics industry
  - Compression into bricks
  - Addition to bitumen road surfacing
  - Creation of macro-plastics
    - Road bollards
    - Park benches
    - Other uses
PlasScRoad is lighter and more durable than asphalt. In the future, streets in the Netherlands might be paved with PlasSc. According to the Guardian, RoAerdam City Council is considering testing out a recycled PlasSc surfacing material, called PlasScRoad, that Dutch construction company VolkerWessels is currently designing.

July 16th 2015
“PlasticRoad” is lighter and more durable than asphalt. In the future, streets in the Netherlands might be paved with plastic.

According to the Guardian Rotterdam City Council is considering testing out a recycled plastic surfacing material, called PlasticRoad, that Dutch construction company VolkerWessels is currently designing.

July 16th 2015
Now for my most cherished and innovative Australian project
The amazing Kiwirrkurra community

Area size = equivalent to Germany
Area population ~2,600
The amazing Kiwirrkurra community
The amazing Kiwirrkurra community
The amazing Kiwirrkurra community
The amazing Kiwirrkurra community
The amazing Kiwirrkurra community is turning this
The amazing Kiwirrkurra community

into this
Time Check
Waste water disposal
Post-filter, used dialysate

Options

Drain to Sewer

Current easy option

Absolutely NOT Drain to Rockpit

Current best option (if available) Drain to Agar's mad dream
Post-filter, used dialysate

Options

- Drain to Sewer
- Drain to Septic
  - Absolutely NOT
  - Current easy option

See HDC ‘Kidney Views’: Agar JWM ‘Poo and Goo’ Blog
Post-filter, used dialysate

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Drain to Agar’s Mad Dream
Post-filter, used dialysate

Spent dialysate is brackish water
It is ‘estuarine’ quality water that contains
• Sodium chloride (= ‘the problem’)
• Potassium
• Calcium, phosphate and magnesium
• Urea nitrogen
= all the nutrients needed for plant aquaculture

And ... marine plants will grow in it
• Seaweeds
• Mangroves
• Sea grasses

This is worth thought
**Effluent dialysate**

- Most current dialysis uses a dialysate flow rate of 500-600ml per minute per patient
- Dialysate is, in effect, slightly diluted seawater
- It removes wastes from the patient on dialysis
- The wastes that dialysate ‘acquires’ include:

<table>
<thead>
<tr>
<th>Human waste</th>
<th>Plant nutrient equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Urea</td>
<td>Urea nitrogen</td>
</tr>
<tr>
<td>• Potassium</td>
<td>Potash</td>
</tr>
<tr>
<td>• Phosphate</td>
<td>Super phosphate</td>
</tr>
<tr>
<td>• Magnesium</td>
<td>Magnesium</td>
</tr>
<tr>
<td>• Calcium</td>
<td>Calcium</td>
</tr>
<tr>
<td>• Zinc</td>
<td>Zinc</td>
</tr>
<tr>
<td>• Other trace elements and salts</td>
<td>Other trace elements and salts</td>
</tr>
</tbody>
</table>
And we do nothing with it

It is lost to drain
So ... I ‘wondered’ ... if effluent dialysate is, in effect ... 

– ‘Nutrient rich’ seawater

– ‘Salty water’ but with super-added:

• Urea nitrogen
• Phosphate
• Calcium
• Potassium
• Other trace substances

\[ \text{all the things} = \text{that land plants need to grow well} \]
So ... I ‘wondered’ ... if effluent dialysate is, in effect ...

- ‘Nutrient rich’ seawater

- ‘Salty water’ but with super-added:

  • Urea nitrogen
  • Phosphate
  • Calcium
  • Potassium
  • Other trace substances

  = all the things that land plants need to grow well

**Question** ... might sea-based plants grow in it?
## Tapwater vs. Seawater vs. Effluent dialysate

### Biochemistry

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>Tap Water</th>
<th>Sea Water</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>p<strong>H</strong></td>
<td></td>
<td>5.5 – 9.0</td>
<td>7.9</td>
<td>7.5</td>
</tr>
<tr>
<td>Na**+**</td>
<td>mg/L</td>
<td>10 – 300</td>
<td>11,000</td>
<td>3,100</td>
</tr>
<tr>
<td>Cl**−**</td>
<td>mg/L</td>
<td>0 – 250</td>
<td>10,000</td>
<td>4,000</td>
</tr>
<tr>
<td>K**+**</td>
<td>mg/L</td>
<td>0.5 – 1.5</td>
<td>700</td>
<td>200</td>
</tr>
<tr>
<td>Ca**++**</td>
<td>mg/L</td>
<td>5.0 – 50</td>
<td>460</td>
<td>47</td>
</tr>
<tr>
<td>PO<strong>4</strong>⁻</td>
<td>mg/L</td>
<td>&lt;0.3</td>
<td>0.09</td>
<td>13</td>
</tr>
<tr>
<td>Mg**++**</td>
<td>mg/L</td>
<td>0.2 – 60</td>
<td>1,500</td>
<td>13</td>
</tr>
<tr>
<td>Urea</td>
<td>mmol/L</td>
<td>&lt;10</td>
<td>0.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Osmolality</td>
<td></td>
<td>Not Known</td>
<td>1124</td>
<td>289</td>
</tr>
</tbody>
</table>
This seaweed pictured here has been ‘grown’ in effluent dialysate for 28 days and in that time has gained a mean 29.7% in healthy weight
Uses of Seaweed

Include – but are not restricted to ...

• Agricultural fertilizers
  » Drift Seaweed
  » Corraline algae
  » Liquid seaweed extracts

• Seaweed industrial gums
  » Alginates
  » Agars
  » Carrageenans

• Cosmetics

• Medicinal uses

• Human uses
  » Food
  » Seaweed baths

• Animal (pet-food) meal
Why should we worry about effluent?
Sorbent dialysis

Are sorbents the future of dialysis?

Who knows ... though I believe it is likely...

And ...

• What is known is that a lot of the new technology is, in some way or other, using sorbents
We will need another use for the used sorbent

(even if it is salty)

For once
we should plan for sustainable disposal before we start
Finally

This should all be done in a purpose-built facility that is
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eco-responsive 

carbon footprint light
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c
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passive within in its’ environment
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carbon footprint light

passive within in its’ environment

and

internally living-friendly

See our eco-website  www.greendialysis.org  for architectural sketch drawings
Another Time Check

? skip 6 slides
The Influence of Light
The single study of light exposure in dialysis

Nagase S et al.

Light-shielded hemodialysis prevents hypotension and lipid peroxidation by inhibiting nitric oxide production.

This data was reported in Clinical Chemistry but not in the dialysis literature.
The single study of light exposure in dialysis

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– 10 stable anuric haemodialysis (HD) patients

– Alternating treatments

1. Standard HD

2. Light-shielded HD

... the blood circuitry + dialyzer are wrapped in aluminium foil to shield the extracorporeal circuit from light
Results - Nagase

Light shielded patients showed …

- Significantly lower plasma NO concentrations
- Significantly less plasma lipid peroxidase (PCOOH) concentrations
- Significantly less plasma thiobarbituric acid concentration (= an index of ‘oxidizability’)

… when compared with standard HD patients
Plasma NO significantly lower in light-shielded HD (solid line) c/w that of unshielded conventional HD (dashed line).

One-way ANOVA, P < 0.05; CV = 5.3%.

The fall in BP at the end of light-shielded HD (solid line) is significantly less than that seen in ordinary HD (dashed line).

Paired t-test, P < 0.05.

Plasma [PCOOH] significantly higher at the end of unshielded conventional HD (dashed line) vs light-shielded HD (solid line).

Paired t-test, P < 0.05; CV = 6.1%.
An inescapable conclusion

These observations:

– the increase in nitric oxide
– the increase in lipid peroxidation
– the increase in oxidative end products
An inescapable conclusion

These observations:

– the increase in nitric oxide
– the increase in lipid peroxidation
– the increase in oxidative end products

When taken together with ...

– an increase in circulatory instability as the outcome

... demand further investigation ... and thought
Just think about it ... 

the environmental light that shines on exposed blood lines ... hour after hour ... 

**might actual matter**

And the wavelength of **fluorescent light** is the most harmful light of all!
Summary
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Summary

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Our world is warming
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and
We can all make a difference – in all we do
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We are significantly responsible for that and
We can all make a difference – in all we do
Dialysis practice can easily be changed

We can all learn to:

– Be more frugal with water use
– Re-use what and where we can
– Explore alternative energy solutions
– Think more carefully about how we handle waste
– Reuse, recycle and regenerate

In the end:

– We can all act more responsibly than we have till now
Thinking green is NOT rocket science!
It is simple common sense
Thank you for listening
Questions/Discussion