Direct Peritoneal Resuscitation: A new adjunct in patients undergoing damage control laparotomy

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Background

Damage control surgery (DCS)

- Damage control surgery (DCS)
  - Balanced resuscitation with RBCs:FFP:platelets (1:1:1) in bleeding patient
  - Control of **bleeding** and/or **contamination** with source control and <u>delay</u> in definitive surgery until patient stabilized and resuscitated
  - OR time is one of the biggest predictors of post operative outcomes
- Ongoing resuscitation in ICU
  - Early correction of hypothermia/acidosis/hypovolemia
  - Maintain perfusion with continued resuscitation and inotropic agents as needed
- Return to OR for definitive repair and fascia closure once hemodynamics parameters have normalized

Approach to critically ill patient with intra-abdominal catastrophe

- Despite adequate resuscitation and source control, patients can still progress to organ dysfunction
- Shock -> profound vasoconstriction -> preferential shunting to brain, heart, kidneys (liver/bowel at risk)
- Bowel hypoperfusion -> severe prolonged inflammatory response -> bowel edema -> **difficulty closing fascia (closure rate after DCS 50-70%)**
  - Release of damage-associated molecular pattern molecules (DAMPs) and proinflammatory cytokines
  - Bacterial translocation
  - Bowel edema/retroperitoneal edema
  - Loss of domain
- Complications of the open abdomen:
  - Ventral hernias
  - EC fistulas (7.1-25% rate after DCS)
  - Abdominal compartment syndrome
  - Prolonged mechanical ventilation (MV)
  - Prolonged ICU and hospital LOS

Can direct peritoneal resuscitation achieve early fascial closure and reduce complications?

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Review

Direct Peritoneal Resuscitation: A review

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DPR instills hypertonic solution into the abdomen in addition to IV resuscitation

Set-up

- 19F Black drain placed in LUQ directed around root of mesentery along left pericolic gutter and down into pelvis
- X-ray cassette cover placed over abd contents but under fascia
- OR towel over plastic cover
- Another drain within towel
- Cover abd w/ Ioban dressing
- Place to low continuous suction
- Instill Deflex (DPR solution)
  - 500cc initially
  - 1.5 mL/Kg/hr until abd closure

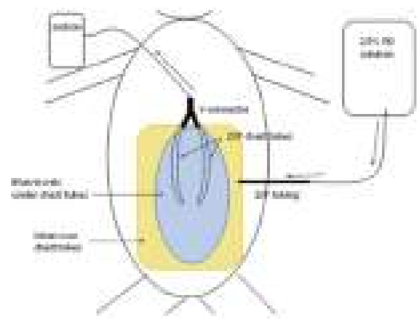

Fig. 4. Set-up for continuous DPR in patients with an open abdomen.

DPR causes rapid vasodilation and improves visceral organ blood flow after shock

- In the hemorrhage model (HS), MAP responded to resuscitation and returned to pre-hemorrhage levels in both conventional resuscitation (CR) and DPR animals
- Liver blood flow returned to normal in CR and DPR groups after resuscitation
- In CR group, liver blood flow falls as soon as resuscitation is complete
- **DPR improves visceral blood flow after shock**

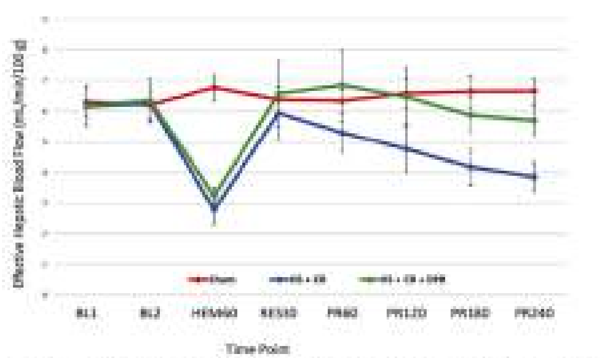

Fig. 2. Use of DPR prevents a reduction in hepatic blood flow compared to CR (BL – Baseline, HEM – hemorrhage, PR – post-resuscitation).

Animal model continued

Post-mortem histologic exam and immunohistochemistry staining showed that DPR:

- Reverses endothelial cell dysfunction
- Downregulates inflammatory response
- Improves cellular architecture (villi sloughing, loss of crypts)
- Reduces tissue edema (lung, liver, ileum)

Direct Peritoneal Resuscitation Accelerates Primary Abdominal Wall Closure after Damage Control Surgery

Jason W Smith, MD, R Neal Garrison, MD, FACS, Paul J Matheson, PhD, Glen A Franklin, MD, FACS, Brian G Harbrecht, MD, FACS, J David Richardson, MD, FACS

- Question: does DPR affect (1) amount of and timing of resuscitation, (2) reduce time to abdominal closure (3) reduce intra-abdominal complications?
- Retrospective case-control study (n=60; DPR group=19, control group =40)
- Study period 1/1/2004-6/30/2008
- Inclusion criteria: all trauma patients with hemorrhagic shock requiring DCS
- Exclusion criteria: a single early death was excluded because of inability to control ongoing hemorrhage, head injuries with an Abbreviated Injury Score >3

Journal of the American College of Surgeons (2010)

Table 1. Comparison of Study Groups

Variables	Control group (n = 40), mean ± SD	DPR group (n = 19), mean ± SD	p Value	W
Age, y	30.7 ± 12.8	30.9 ± 12.5	0.96	0.89
HR (bpm), presenting	107 ± 36	109 ± 35	0.91	0.86
SBP (mmHg), presenting	90 ± 28	88 ± 28	0.72	0.51
Injury Severity Score	34 ± 16	36 ± 17	0.63	0.93
pH, presenting	7.26 ± 0.14	7.25 ± 0.12	0.74	.095
pH, 24 h	7.36 ± 0.06	7.38 ± 0.04	0.83	0.22
Base deficit, presenting	7.8 ± 4	8.0 ± 2.6	0.89	0.21
INR, presenting	1.4 ± 0.5	1.7 ± 0.5	0.026	0.88
INR, 24 h	1.2 ± 0.4	1.1 ± 0.4	0.27	0.07
ALT (IU), presenting	508 ± 943	742 ± 1,296	0.43	0.24
ALT (IU), 24 h	762 ± 1,329	717 ± 934	0.89	0.55
AST (IU), presenting	757 ± 1,250	1,200 ± 1,900	0.28	0.09
AST (IU), 24 h	1025 ± 98	984 ± 1,172	0.92	0.49
BUN, presenting	12 ± 4	13 ± 5	0.49	0.75
BUN, 24 h	15 ± 7	16 ± 6	0.82	0.36
Creatinine, presenting	1.01 ± 0.40	1.11 ± 0.35	0.30	0.65
Creatinine, 24 h	1.23 ± 0.58	1.32 ± 0.51	0.56	0.31
IV fluid (L), first 24 h (L)	23 ± 7	25 ± 11	0.51	0.15
Blood products, U, first 24 h	22 ± 12	27 ± 14	0.24	0.49

ALT, alanine transaminase; AST, aspartate transaminase; bpm, beats per minute; DPR, directed peritoneal resuscitation; HR, heart rate; INR, international normalized ratio; IU, international units; SBP, systolic blood pressure.

Results

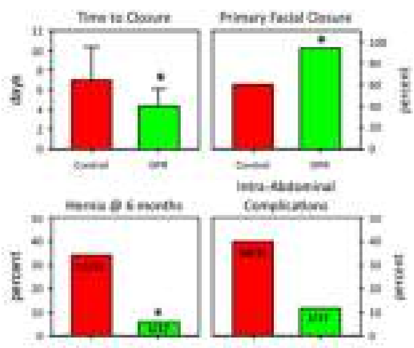

Figure 1. Demonstrating the significant differences between the control group and the directed peritoneal resuscitation (DPR) group. * indicates statistical significance.

Table 2. Group Outcomes Data

Variable	Control (n = 40)	DPR (n = 19)	p Value	W
Hospital LOS, d, mean ± SD	25 ± 15	24 ± 16	0.79	0.75
ICU LOS, d, mean ± SD	16 ± 12	16 ± 11	0.98	0.80
Ventilator, d, mean ± SD	10 ± 7	12 ± 9	0.063	0.28
Mortality, n (%)	5 (12.5)	2 (10.5)	NA	NA

DPR, directed peritoneal resuscitation; LOS, length of stay.

Results

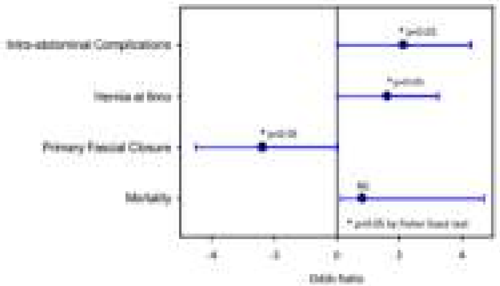

Figure 2. Odds ratio of significant variable between control and directed peritoneal resuscitation (DPR) group showing a decrease rate of hernia formation, increased primary fascial closure rate, and lower number of intra-abdominal complications.

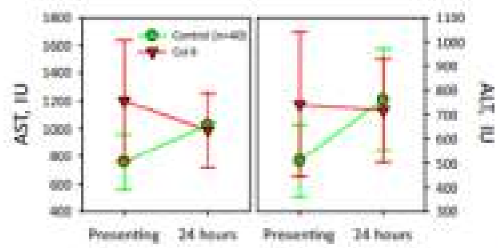

Figure 3. Liver enzymes levels in the control versus directed peritoneal resuscitation (DPR) groups showing a trend toward improvement in the DPR group compared with worsened aspartate transaminase (AST)/alanine transaminase (ALT) levels at 24 hours in the control group. IU, international units.

Conclusion

- Use of DPR after DCS for hemorrhagic shock:
  - Decreased time to definitive abdominal closure
  - Increased rate of primary fascial closure
  - Reduced rates of intra-abdominal complications (EC fistulas, hernia, etc)

AAST 2013 PLENARY PAPER

Adjunctive treatment of abdominal catastrophes and sepsis with direct peritoneal resuscitation: Indications for use in acute care surgery

Jason W. Smith, MD, PhD, R. Neal Garrison, MD, Paul J. Matheson, PhD, Brian G. Harbrecht, MD, Matthew V. Benns, MD, Glen A. Franklin, MD, Keith R. Miller, MD, Matthew C. Bozeman, MD, *and* J. David Richardson, MD, *Louisville, Kentucky*

- Hypothesis: the beneficial effects of DPR would exist in patients undergoing DCS for nontraumatic, emergency general surgery indications
- Sequential prospective, propensity-matched study
- Enrollment 1/2008-12/2012
- n=118 (control n=67, DPR n=51); after propensity scoring 44 pts/grp
- Inclusion criteria: age 18-80, patient with sepsis requiring DCS (pancreatitis, perforated hollow viscous, bowel obstruction, and ischemic enterocolitis)

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Methods

- Study phases
  - Phase one (1/2008-9/2010) - all patients undergo DCS with standard closure and resuscitation
  - Phase two (10/2010-12-2012) - all patients undergo DCS with DPR in addition to standardized resuscitation and closure technique
- Propensity matched groups were created matching for severity of illness
- Outcome variables
  - Length of stay (LOS); ICU LOS, mortality, time to and type of definitive abdominal closure, volume of blood transfused in the first 24 hours and 48 hours, and volume of crystalloid transfused in the first 24 hours and 48 hours, complications

TABLE 1. Study Population and Variables Collected During the 24-Hour Period of Initial Operation (Mean [SD])

	Open Abdomen Control (n = 67)	Open Abdomen DPR (n = 51)	*p*
Age	61 (21)	54 (16)	0.01*
Sex, male, n	41	29	—
HR	125 (29)	112 (40)	0.04*
SBP, mm Hg	98 (22)	89 (33)	0.07
MAP	57 (18)	65 (23)	0.11
Respiratory rate	16 (6)	22 (9)	0.001*
Temperature (°F)	101 (4)	100 (3)	0.14
GCS score	10 (3)	12 (6)	0.07
pH	7.19 (0.34)	7.11 (0.40)	0.24
P_{CO_2}, mm Hg	59 (15)	53 (12)	0.02*
Pa_{O_2}, mm Hg	64 (19	59 (17)	0.14
Base deficit	7 (4)	8 (4)	0.18
FIO_2 (fractional %)	100	100	—
Na^+, mEq/L	133 (15)	141 (20)	0.01*
K^+, mEq/L	3.4 (1.1)	4.1 (1.3)	0.04*
CO_2, mEq/L	14 (8)	16 (9)	0.20
BUN, mg/dL	30 (14)	35 (22)	0.36
Serum Cr, mg/dL	1.8 (1.1)	1.8 (0.9)	0.29
WBC, $\times 10^9$/L	12 (11)	15 (9)	0.11
Hct, %	37 (24)	35 (21)	0.34
Platelet, $\times 10^3/\mu L$	109 (55)	143 (88)	0.01*
Urine output, mL/h	38 (22)	29 (35)	0.09
Total bilirubin, mg/dL	1.3 (1.1)	1.1 (0.8)	0.28
Vasopressor use, n	41	40	—
Severe organ dysfunction prior to operation, n	3	2	—
Mechanical ventilation, n	67	51	—

TABLE 2. Propensity-Matched Case Cohorts With Mean (SD) and *p* Value During the 24 Hours After DCS

	Open Abdomen Control (n = 44)	Open Abdomen DPR (n = 44)	*p*
Age	52 (12)	50 (8)	0.36
Sex (n male)	27	25	—
HR	121 (40)	111 (40)	0.20
SBP, mm Hg	91 (40)	87 (32)	0.60
MAP	55 (35)	59 (25)	0.50
Respiratory rate	22 (6)	20 (11)	0.29
Temperature (°F)	100.2 (3.3)	101 (3.1)	0.21
GCS score	11 (3)	10 (3)	0.15
pH	7.15 (0.39)	7.12 (0.44)	0.7
P_{CO_2}, mm Hg	57 (14)	55 (13)	0.49
Pa_{O_2}, mm Hg	60 (16)	57 (13)	0.33
Base deficit	7 (3)	7 (4)	—
FIO_2 (fractional %)	100	100	—
Na^+, mEq/L	139 (22)	141 (19)	0.49
K^+, mEq/L	4.0 (1.4)	4.5 (1.5)	0.73
CO_2, mEq/L	16 (8)	17 (10)	0.61
BUN, mg/dL	29 (11)	35 (22)	0.11
Serum Cr, mg/dL	1.6 (0.6)	1.8 (0.9)	0.22
WBC, $\times 10^9$/L	14 (12)	15 (9)	0.65
Hct, %	40 (19)	33 (22)	0.11
Platelet, $\times 10^3/\mu L$	140 (68)	123 (77)	0.27
Urine output, mL/h	30 (22)	23 (30)	0.21
Total bilirubin, mg/dL	1.3 (1)	1.2 (0.7)	0.59
Vasopressor use, n	27	26	—
Severe organ dysfunction prior to operation, n	0	0	—
Mechanical ventilation, n	44	44	—

Results

TABLE 6. Propensity-Matched Cohort Outcome Variables

	Controls (n = 44)	DPR (n = 44)	*p*
No. trips to the operating room	4 (2)	3 (2)	0.02
→ Time to definitive abdominal closure, d	7.7 (4.1)	5.9 (3.2)	0.02
→ Primary fascial closure, n (%)	19 (43)	29 (68)	0.03
→ No. abdominal complications	21 (47%)	12 (27%)	0.04
→ Ventilator days	14 (6)	10 (5)	0.01
→ ICU LOS, d	24 (11)	17 (9)	0.002
Total LOS, d	41 (13)	35 (16)	0.06
ICU-free days	26 (11)	31 (13)	0.05
Mortality, n (%)	12 (27)	7 (16)	0.15

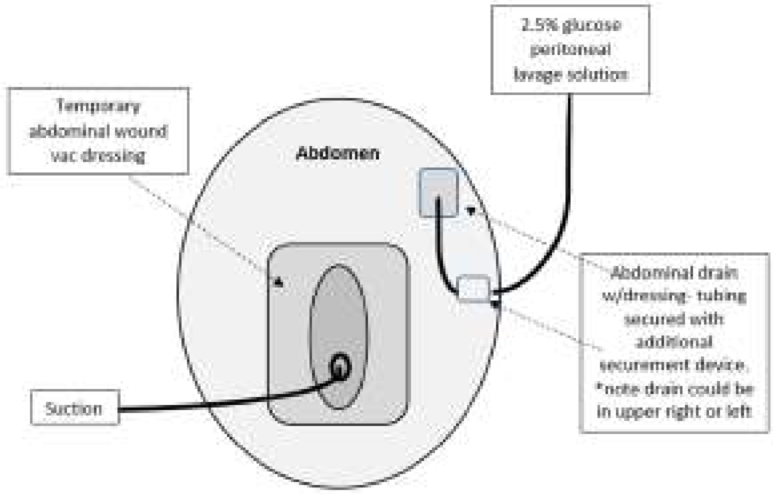
DPR procedure/process development in a medical surgical ICU

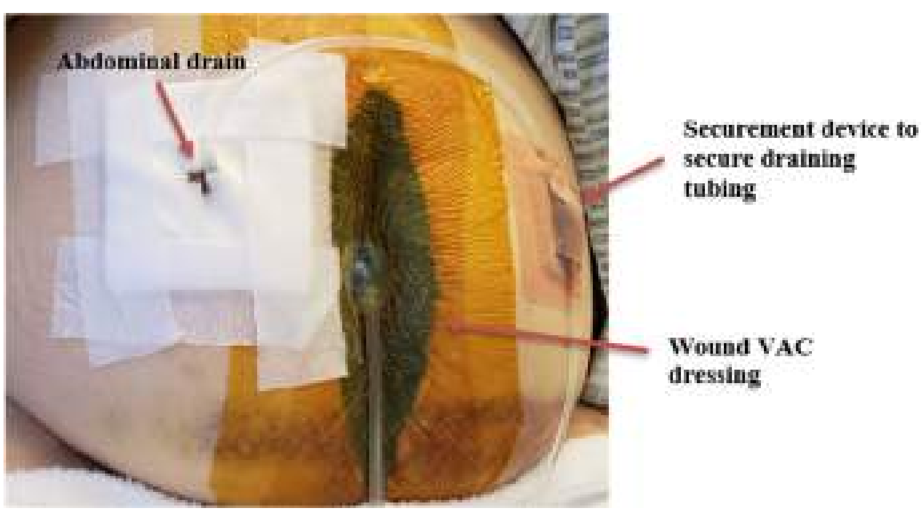
Quality Improvement Project

- Develop procedure
- Create orders
- Identify/obtain supplies
- Ensure safety
- Education/training
- Monitor outcomes

DPR Setup

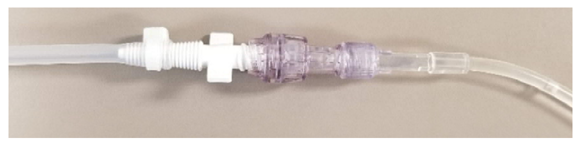
- Abdominal channel drain to deliver hypertonic peritoneal solution (400mL/hr) into peritoneal cavity
- Wound vacuum-assisted closure (VAC) dressing to continuous suction, used to remove solution





DPR Setup Challenges

- Premade 2.5% dextrose peritoneal dialysis solution (5L bag) used for hypertonic solution
  Challenge: hooking IV tubing to bag made to connect to peritoneal dialysis tubing
- IV pump utilized to infuse hypertonic solution into a drainage catheter
  Challenge: connecting IV tubing to a channel drain
  Safety: risk of IV tubing being reconnected to an intravenous line
- Wound VAC dressing suction source
  Challenge: wound VAC machine canisters only hold 500mL



Safety

NOT FOR INTRAVENOUS USE

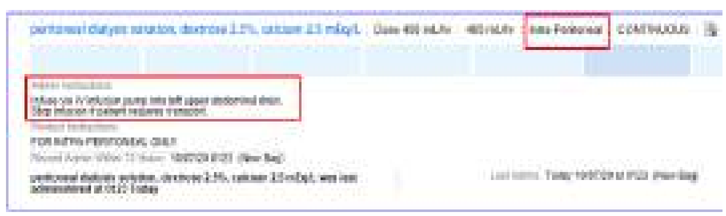
Peritoneal solution ran through IV tubing & infusion pump into abdominal drain

- **Pink** 'Not for Intravenous Use' labels (solution bag, IV pump, distal end of IV tubing)
- Designated IV pole, positioned on opposite side of bed from other IV pumps
- Narcotic IV tubing used for no extra infusion ports
- Picture setup part of procedure & tip sheet
- Route for solution on MAR in EHR listed as intra-peritoneal

Other Considerations

- I & O documentation:
  - Identify EHR rows to flow to correct location on the intake and output reports
- Supplies:
  - 2L suction canister vs 1L
  - Supply kit for setup with tip sheet
  - Adequate supply of peritoneal dialysis solution (bag lasts ~12hrs)
- Transport:
  - Stop hypertonic solution infusion and disconnect, transition suction to wound VAC machine
- CRRT:
  - Worked with nephrology on how to manage fluids in CRRT patients

Orders



Panel order within EHR:

- Dextrose peritoneal dialysis solution: intra-peritoneal route
- Wound VAC dressing order:
  - Guided in suction levels
  - Assessment
  - Transport
- Abdominal drain:
  - Indication (instillation of solution)
  - Management for transport
- Automatic warming device
  - Utilize to maintain normothermia

DPR Procedure

- Guides with pictures in initial step by step setup
- IV tubing setup and tubing change time
- I & O documentation
- Patient transport
- Safety- IV pump setup
- Intra-abdominal pressure monitoring

- Tip sheet for bedside reference
  - Supplies & setup
  - Orders
  - Assessment/documentation

Education

- Why and how
- Showed drain, setup, supply kit
- Nursing cares
  - Assessment/monitoring
  - Fluid status
  - Patient positioning/skin
  - Temperature management
  - Electrolyte monitoring
- Nuances
  - Suction connection
  - Transitioning to wound VAC machine
  - Hourly I&O management

ANW Preliminary Data

- 16 patients
- 12.5% mortality (1 transitioned to comfort care after index operation)
- Mean time from DPR start to fascial closure: 68 hours
    - Median time 47 hours
- 3 median trips to the OR
- 2 complications related to surgery (12.5%) [so far]
    - 1 Enteric leak
    - 1 takeback for bleeding
- 1 did not achieve primary fascial closure

Conclusion

- Use of DPR after DCS for intra-abdominal catastrophe:
    - Decreased time to definitive abdominal closure
    - Increased rate of primary fascial closure
    - Reduced rates of intra-abdominal complications (EC fistulas, hernia, etc)
    - Decreased MV days
    - Decreased ICU LOS

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