10. Fixing Rib fractures is beneficial


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Comparative effectiveness of the C MAX video laryngoscope versus direct laryngoscopy in the setting of predicted difficult airway. Aziz MR, Dillman D, Fu R, Brambrink AM. *Anesthesiology* 2012; 116:629-36


6. Debate continues regarding the optimal resuscitation fluid; should chloride be avoided?


Association between a chloride-liberal vs chloride-restrictive intravenous fluid administration strategy and kidney injury in critically ill adults. *JAMA* 2012; 308: 1566-72


**Annotated references**

10 Fixing Rib Fractures is Beneficial

The definition of a flail chest is a chest wall instability caused by fractures of ribs in two or more locations of the same rib such that there is a segment of the chest wall that paradoxically moves during inspirations (i.e. collapses inward) and expiration (i.e. pushes outward).

Slobegean and colleagues performed a systematic review of the published literature looking for papers that reported the outcome following operative versus nonoperative management of flail chest. The reviewers identified eleven papers that met their criteria that included reports of direct comparisons of more than ten patients in two groups; one group whose ribs were stabilized and one group whose ribs were not stabilized. They pooled the data, and analyzed the data using rigorous meta-analysis techniques; for example the pooled data was first analyzed, and then the analyses repeated ten times after removing patient’s from each of the papers to determine if a single paper’s was an outlier or appeared to introduce a bias. The studies were from eight different countries and a range of operative techniques were used from Kirschner wires to struts screwed into the rib.

The results of the Slobegean et al analysis was improved outcome in the patients who had operative fixation of their ribs. The specific measures that showed improvement in favor of the patients who received operative fixation are summarized in the table.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Change in favor of surgery cohort</th>
<th>Range of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased ventilator days</td>
<td>8</td>
<td>5.2 – 11.4 (95% confidence interval)</td>
</tr>
<tr>
<td>Decreased ICU days</td>
<td>7</td>
<td>1.8 – 11.5 (95% confidence interval)</td>
</tr>
</tbody>
</table>
Odds of pneumonia | 0.2 | 0.11 – 0.32 (95% confidence interval)
Mortality | 0.3 | 0.20 – 0.48 (95% confidence interval)
Tracheostomy | 0.06 | 0.02 – 0.20 (95% confidence interval)

The authors identify that a major weakness of their pooled analysis is the majority of the studies are retrospective, and small, and are certainly subject to bias including publication bias (i.e. the paper is only published if the results following rib fracture plating improved outcome). The authors add the observation that they cannot identify a surgical technique which is “superior” among the multiple included. The authors conclude a strength of their observation is that the results were consistent across the eleven studies performed in widely dissimilar hospital; for example the benefit of reduced ventilator days was very consistent; see below.

The authors table is a sensitivity analysis of how many fewer days the operative group needed mechanical ventilation compared to the other group, and on the average seven fewer days of ventilation were needed. It is important to keep in mind that the authors are studying patients who had a diagnosis of flail chest, and therefore the patients distress during mechanical ventilation may have been an impaired ability to generate a robust cough- based in part on chest wall instability.

Conclusion from this study is a cautious but very consistent demonstration that rib fracture repair may improve patient outcome. Because 80% of these studies were not randomized, a selection bias exists; that is to say the patients with flail chest who were not selected for surgery were more seriously injured, and had other risk factors that dissuaded the surgeon from trying a surgical fixation.

In this study from Australia, Marasco and colleagues report the results of a prospective randomized control trial of a selected subset of patients admitted following trauma who had rib fractures; the patient met the criteria of a flail chest; “three or more consecutive ribs fractured in more than one place, producing a free-floating segment of chest wall.”. An additional inclusion requirement was that the patients “were ventilator dependent with no prospect of successful weaning within the next 48 hours.” Over a five year period the authors recruited 46 patients into the study; half had rib repair surgery.

The characteristics of the two groups were similar; average age of 58, all blunt trauma, 87% male, aver injury severity scores were high at 32.5 indicating these were typical seriously multiple injured patients, although there only 2 of 46 with a significant brain hemorrhage. The two groups had the same number of identified ribs that were fractured, (n = 11) and the same number of ribs in flail segment (n = 5).

The surgical procedure was performed through one to two skin incisions parallel to the rib, and then exposing the rib fracture using muscle splitting techniques. The surgeons attempted to manipulate the rib fracture end to achieve an anatomical reduction. The plates were 6 or 8 hole plates, the surgeon placed these across only one site of fracture in each rib, and the surgeon screwed bicortical screws through the plate’s foramen’s to secure the plate. The plates were made of a copolymer of polylactide that resorbs over 18 to 24 months.

The patients who had rib fixation had improved outcome by the following measures; shorter ICU length of stay, shorter duration of invasive mechanical ventilation, and fewer tracheostomies (i.e. operative group 39%, nonoperative group 70% P value 0.01). In addition to short term outcome, Marasco and colleagues were able to conduct evaluation of the majority of the patients at three months and those who had operative fixation had a trend toward less chest wall deformity, but these did not show a difference in outcome. At six months post injury, 83% of patient completed a Short Form-36 Quality of Life Questionnaire; the scores of the two groups were identical. However the normative Australian population “physical summary score PCS” for similar individuals is 49.8, which a “bit higher that the scored in the groups in this study.”( Operative PCS 34, nonoperative PCS 35. P = 0.65). In summary the benefits of rib fracture stabilization were short term.

In conclusion, this is a small but rigorously conducted RCT adds to the growing body of literature that patients with a flail chest who are dependent on mechanical ventilation will benefit from surgical stabilization of the ribs. The data from the Marasco et al study indicates stabilization of the chest wall flail segment may enable the patient to ventilate spontaneously, and perhaps generate a better cough to clear secretions. However the long term outcomes did not show benefit. The authors of this study, like any other study that is evaluating a new device, must consider whether they have refined to the maximum effectiveness their rib plate stabilization procedure. Marasco et al recommend further trials with an emphasis on refining the methods of achieving the purpose of the plate, which presumably is to minimize motion, stabilize the flail activity of the chest wall, and provide improved pain control.

9. Clostridiuim difficile remains a threat to trauma patients.
*Clostridium difficile* is a bacteria that can rapidly lead to a severe pan-colitis, septic shock, renal failure and death. *C. difficile* is a major public health concern in the US, Canada and Europe because the incidence of the disease has increased, and there appears to be changes being made in the genetic code of *C difficile*, perhaps in response to antibiotics used to treat it, that has led to the emergence of modified *C difficile* that produces large amounts of lethal toxins which are refractory to conventional treatments. Elder patients, weakened by other illnesses, are very susceptible to *C difficile* infection.

The clinical course of *C difficile* colitis is commonly begun when a patient is treated with antibiotics for an infection. The antibiotics alter the normal fecal flora in the colon and luminal environmental changes encourage conversion of the *C difficile* spore into a rapidly proliferating gram-positive bacillus. Experts assert that certain types of antibiotics increase the risk of induction of *C difficile* colitis; these include clindamycin, second and third generation cephalosporins, (especially ceftriaxone) and fluoroquinolones. The toxicity of *C difficile* colitis is primarily a function of two toxins produced by the bacteria. The two toxins, TcdA and TcdB, are produced in the bacterium, translocate into mucosal cells of the colon, where these toxins cause cell death. Damage to the mucosa cells is manifest as voluminous diarrheal stools. While most patients have a less than fulminant infections, a minority of patients absorb toxins into the blood stream from the colonic lumen. These toxins are hypothesized to incite an inflammatory response that can cause lethal systemic shock syndrome.

The diagnosis of *C difficile* colitis is made by submitting a liquid stool sample to enzyme (polymerase chain reaction) immunoassay for toxin; results can be back within an hour, as the test is simple. Experts concerned about false positive immunoassay results recommend that confirmation of the toxins’ presence in stool should be accomplished with a cytotoxicity assay. Confirmation of the *C difficile* colitis can be made by passing a colonoscopy which will reveal in patients with colitis with a characteristic appearance of “pseudomembranes”; yellow to white adherent areas of purulence. Using the tip of the colonoscope to push the adherent areas off the surface to the colon’ mucosa, the endoscopist will expose a bleeding surface. The toxins kill mucosal cells resulting in stools that a positive for fecal leukocytes and blood. Patients can progress to a toxic mega-colon-acute dilation of the entire colon producing a tense painful abdominal distention. The onset of the abdominal compartment syndrome is a pre-lethal manifestation of *C difficile* colitis. Many clinicians evaluating a patient for *C difficile* colitis obtain a CT of the abdomen, which reveals the extent of colitis (the worse is pan colitis from cecum to the rectum).


In this observational study of ten years of data from the nations Inpatient Sample, the investigators learned that the yearly hospitalizations estimated to occur in the US of patients with a diagnosis of *C difficile* colitis increased from 150,000 in 2001 to 350,000 in 2010. During the period of increased numbers of cases, the number of colectomies increased 0.5% per year in 2001 to 0.8% per year in 2010. The outcomes of patients who have a colon resection for *C difficile* toxic colitis has remained stable at 30% with, in addition, a high rate of prolonged hospitalization and final hospital discharge dispositions in
the majority of patients to nursing facilities. The authors point out the patients who come to colon resection for C difficile colitis have typically a long list of co-morbid conditions, and that future improvements in outcome may depend as much on identification of risk factors “that will help better patient and family counseling, decision making and risk stratification.”


Treatment of patients with C difficile colitis is oral antibiotics that passed through the stomach and small bowel are delivered to the colon and are cytotoxic to the C difficile bacterium. In clinical syndromes of mild colitis confirmed to be C difficile, metronidazole 500 mg PO three times a day is preferred therapy. If the patient has systemic toxicity (elevated WBC, increasing renal dysfunction, hypotension) most authorities recommend vancomycin 125 mg PO four times a day. If the patient has severe complicated colitis, particularly an ileus with limited peristalsis, most authorities recommend IV metronidazole (500 mg IV TID) plus vancomycin at the dose of 500 mg PO four times per day, and recent reports have indicated vancomycin enemas may be highly effective in patients with colonic ileus. The precipitating cause for C difficile colitis is administration of antibiotics to treat an infection; for example pneumonia or cellulitis or even a single dose given for prophylaxis before surgery on fracture. Surgeons treating C difficile colitis should always strongly consider stopping the antibiotics that may have induced the conversion of C difficile spore to bacterium.

The majority of patients respond to oral antibiotics, although there is a ~20% reported prevalence of “recurrent” C difficile requiring a second course of therapy. There are anecdotal reports that C difficile risk can be reduced by administration of oral administration of probiotics, usually in the form of yogurt that contains normal bacteria that repopulate the colon.

Approximately 10 to 15% of patients with C difficile colitis progress in the severity of their clinical syndrome. These patient develop signs and symptoms of a toxic megacolon, shock, tense distended
abdomen, markedly elevated WBC and other signs of severe systemic toxicity such as renal failure and acidemia. Surgeons have reversed a rapidly deteriorating multiple organ dysfunction syndrome by performing a subtotal colectomy and ileostomy. Recent papers have proposed that less aggressive surgical resection may be effective.


There is near universal agreement among surgeons that if a patient develops toxic pan-colitis (“fulminant C difficile associated disease”) a surgeon should perform a subtotal colectomy to eliminate the absorption of toxin from the damaged mucosa. This can be a daunting decision because when the laparotomy is performed the external surface of the colon may appear to have minimal abnormality. In this paper from the University of Pittsburgh School of Medicine, Neal and coauthors report a favorable experience with performing a loop ileostomy, inserting a catheter into the distal lumen, irrigating the colon with 8 liters of warmed polyethylene glycol 3350 (the Golytely solution used for bowel prep) while having inserted into the rectum a large diameter tube that enables drainage of the irrigation flush. After the colon has been flushed, the authors then irrigate into the colon a solution of 500 mg of Vancomycin in 500 ml of lactated Ringers every 8 hours for ten days. In addition the patients are given intravenous flagyl.

Neal and colleagues report 43 patients with severe, complicated C difficile associated disease who had a laparotomy. In 42 patients the surgeons performed a diverting ileostomy and irrigation. The patients were seriously ill, with 74% needing vasopressor support, and 64% on mechanical ventilation. Immunosuppression drugs were being given to 45%, and the mean serum albumin level was 2.0 +/- 0.8 g/dL. The surgeons were able to accomplish the procedure using laposcopic techniques in 83% of the patients. 40 of the patients had an initial improvement. The mean time to return of bowel function was 3 +/-2 days. Two patients had delayed subtotal colectomy because they developed recurrent signs of the abdominal compartment syndrome and continued to require vasopressor support.

The death rate was high in this group of patients, but these deaths were attributed by the surgeons to the pre-existing severe diseases. Within 30 days, 19% of ileostomy and washout patients died, and another 14% of patients died more than 30 days post op. Complications occurred in a few patients including surgical site infection, need to revise the ileostomy, and ileostomy tube problems. As of the time of the authors report of this series of 42 patients with ileostomy and colonic irrigation, only four of the long term survivors (n = 21) had returned for takedown of their ileostomies.


In this follow up report, the authors from the University of Pittsburgh state “Our group has currently managed more than 70 patients with C difficile associated disease”. The authors report 5 patients had an unsatisfactory post-op course. They develop the abdominal compartment as the vancomycin
containing fluids were irrigated into their colon, and were subsequently treated with either a subtotal colectomy or a decompressive laparotomy. Carchman and co-authors report that they have concluded that if the abdominal compartment syndrome develops in a patient with *C difficile* colitis, the best course of treatment is a subtotal colectomy. The authors are very cautious in their recommendations; “Rigorous study and future trials will determine the adequacy of this procedure.” They are convinced their procedure may have merit in selected patients but await the results of prospective studies.

The use of diversion and distal washout may be an example of a procedure that is optimally done earlier in the course of *C difficile* fulminant colitis, a step before the very morbid procedure of a subtotal colectomy and low rectal transection, with its long term limitations for eventual restoring continuity. One thing that experienced surgeons emphasize in recommending treatment of *C difficile* colitis is that judgment is need based upon not just the severity of the toxicity from the colitis, but also the status of the patient who often develops the colitis superimposed on another critical illness.

8 Management of cardiac stab wounds; not all patients need a sternotomy.


Nicol and colleagues from the extraordinarily busy, from a trauma perspective, Groote Schuur Hospital, a trauma center in Cape Town, South Africa report the results of a randomized control trial of the surgical management of patients with penetrating chest trauma, who had hemopericardium, and were hemodynamically stable without evidence of active intra-pericardial bleeding. The surgeons had confirmed the patient had a hemopericardium by performing a subxiphoid pericardial window, a procedure performed by making an incision beneath the xiphoid, dissecting up to the surface of the pericardium, and then cutting an opening into the pericardium. In this study the surgeons randomized patients whose window drained blood, but who were hemodynamically stable and not bleeding, to either have a sternotomy to examine the heart for a wound, or the alternative therapy was irrigation of the pericardium with 500 ml of isotonic saline, and drainage of the pericardium, a considerably less invasive procedure. The rationale for the Cape Town surgeons deciding to do this study was that their experience was that many of the patients who had a stenotomy after a positive subxiphoid pericardial window, did not have a bleeding lesion in the heart or great vessels because the bleeding wound had stopped on its own.

The investigators studied 111 patients over 9 years. During the study period another 348 patient underwent surgery for an obvious or symptomatic pericardial effusion. All of the 111 patients were hemodynamically stable when they were evaluated in the ED, had an ultrasound which demonstrated fluid in the pericardium, and were observed in a “high care unit” with equipment for continuous monitoring. Of the 55 patients randomized to sternotomy, 93% had either “no cardiac injury or a tangential heart laceration” The four patients with a heart puncture had non-bleeding wounds. Of the 56 patients randomized to pericardial irrigation and drainage, all did well and none required further surgery.
There was 1 death postoperatively among the 111 patients (0.9%) and this was a patient in the sternotomy group. The mean intensive care unit (ICU) stay for a sternotomy was 2.04 days (range, 0–25 days) compared with 0.25 days (range, 0–2) for the drainage (P < 0.001).

In conclusion the authors emphasize first that this population is a highly selected subset and represented 32% of the total population with stab wounds to the heart. Their protocol was very successful. However this study must be understood as having been conducted in a trauma center with overwhelming numbers of patients in South Africa where surgical resources are limited. Thus the investigators have developed a practicable solution to providing optimal but efficient care. Their protocol confirmed that reliance upon a subxiphoid window to evacuate pericardial fluid and blood in a hemodynamically stable patient is a safe alternative therapy to more invasive sternotomy incision. A caveat that enables this protocol to be successful may well be that their trauma center’s capacity to closely follow a patient at risk for evidence of deterioration and then respond promptly. In closing, this paper is a continuation of a debate for 50 years as to the optimal method for management of penetrating cardiac wounds, which seem in most cases to either be a catastrophic rapidly lethal wound and an uncomplicated wound manageable with simple drainage.

**Penetrating cardiac trauma.** Brewster SA, Thirlby RC, Snyder WH Arch Surg 1988; 123:937-941

Brewster and colleagues described a series of 108 patients who presented with stab or gun shot wounds around the heart, and no signs of cardiac injury or shock. This series was before ultrasound was routinely used to evaluate the pericardium, and the authors reported performing instead of ultrasound a subxiphoid pericardial windows as a method for determining if there was hemopericardium, and thus performing a thoracotomy. Brewster provides the image below showing their preferred technique for a pericardial window. The pericardial window revealed hemopericardium in 28 patients, all of who had a thoracotomy; 21 of 28 heart/pericardial wounds “required suture repair”.

**7 Video laryngoscopy a new technology that offers added benefit.**

**Comparative effectiveness of the C MAX video laryngoscope versus direct laryngoscopy in the setting of predicted difficult airway.** Aziz MR, Dillman D, Fu R, Brambrink AM. Anesthesiology 2012; 116:629-36.

Video-laryngoscopy has been used with increasing frequency in the management of rapid sequence intubation. Several authors report based on small series that in intubating patients with “difficult airways” the video scope provides a superior image, and enables a higher percent of successful intubations. In this randomized control trial Aziz and colleagues set out to compare tracheal intubation using a C-MAC® video laryngoscope (Karl Storz, Tuttingen, Germany). The authors recruited three hundred patient from 30,000 scheduled to have elective surgery requiring endotracheal intubation; patients were recruited if they had one or more predictors of a difficult intubation. These predictors were: 1. Reduced cervical motion either from pathologic conditions or cervical spine precautions, 2. Mallampati classification III or IV [Mallampati is view of hypopharynx when the patient responds to
“open your mouth and says ah”, 3. Reduced open of mouth to less than 3 cm, &/or 4. History of difficult direct laryngoscopy on previous intubations.

The patients were randomized to have first try of endotracheal intubation following induction of anesthesia either with a direct laryngoscopy or a video laryngoscopy. The results were that the direct laryngoscopy had a 84% success with first try at intubation which was statistically less than the 93% success with first try using the videolaryngoscopy. This greater success of the videolaryngoscopy was attributed to an improved view (93.3% with videolarygoscope and 80.9% with direct laryngoscope) of the larynx on the screen compared to what could be seed with direct laryngoscopy. All of the patients who had a failed first attempt were successfully intubated using a variety of rescue techniques. The providers doing the intubations in this study were 8% attending anesthesiologist, 50% residents and 42% CRNA, with by chance, more residents in the direct laryngoscopy group. There were an equal proportion of patient with minor complications in each group. The author conclude that in the diverse group of providers performing endotracheal intubation in the subset of patients anticipated to have a difficult intubation, the videolaryngoscopy provided superior visualization of the larynx and enabled greater first try success. This supports the conclusion that routine use of the videolaryngoscope is appropriate, but the authors emphasize that this technique is not 100% reliable and the provider must always have a plan for a rescue technique for intubating these challenging patients.


In this retrospective study of patient intubated in the emergency department (~ 50% trauma patients, and 88% Rapid Sequence Intubations) the authors compared success rates using GlideScope® for performing videolaryngoscopy to the success rates of performing the intubation with direct laryngoscopy. In a population of 943 patients, 62% had an attempt at direct laryngoscopy and 38% had the first attempt intubated using videolaryngoscopy. The videolaryngoscopy had a significantly higher (p = 0.03) first attempt success rate (75%) compared to first attempt success rate in the DL group (68%). The overall success rate for intubation was 100%, and in 15% of patients in both groups, the provider needed to switch to an alternative method of laryngoscopy to achieve successful intubation.

<table>
<thead>
<tr>
<th>Initial mode:</th>
<th>1st Attempt success</th>
<th>2nd Attempt Success</th>
<th>Rescue with...</th>
<th>Esophageal intubations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct laryngoscopy</td>
<td>68%</td>
<td>18% with DL</td>
<td>14% rescued with videolaryngoscopy</td>
<td>3.1%</td>
</tr>
<tr>
<td>n = 583</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Videolaryngoscopy</td>
<td>75%</td>
<td>9% with VL</td>
<td>15% rescued with Direct laryngoscopy</td>
<td>0.3%</td>
</tr>
<tr>
<td>N = 360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P value</td>
<td>P = 0.03</td>
<td></td>
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</table>

The authors comment on what they conclude is the reasons for failure unique to each device. Using the videolaryngoscopy, the failures occur because of lens contamination making visualization of the larynx
impossible, or failures occur in a minority of patients because of difficulty passing the endotracheal tube through the cords. Failures in patients having direct laryngoscopy are most commonly due to operator’s inability to view the open glottis; most operators faced with this problem can adjust the patient’s head or use an alternative blade to accomplish glottis exposure.

In conclusion of Sackles et al is that videolaryngoscopy is a safe and generally effective first choice method for performing a rapid sequence intubation in the ED, and when used is more likely to enable first attempt intubation. Nonetheless the provider should always be aware it has its limitations and have a clear fall back “rescue” option including emergency surgical airway.


In this third study additional evidence is provided that videolaryngoscopy is a superior technique for performing rapid sequence intubation in an ICU. The authors emphasize that for less experienced providers performing an emergency rapid sequence intubation, the measures of success were higher when they were using video laryngoscopy. See table below.

<table>
<thead>
<tr>
<th></th>
<th>1st Attempt success rate</th>
<th>Intubated after ≥ 3 attempts</th>
<th>Esophageal intubations</th>
<th>O2 saturation &lt; 80%</th>
<th>Time: sedative to intubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video-laryngoscopy N = 78</td>
<td>91%</td>
<td>4%</td>
<td>0%</td>
<td>16%</td>
<td>3.9 +/- 3 minutes</td>
</tr>
<tr>
<td>Direct laryngoscopy N = 50</td>
<td>68%</td>
<td>20%</td>
<td>14%</td>
<td>24%</td>
<td>13 +/- 6 minutes</td>
</tr>
<tr>
<td>p value</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P = 0.27</td>
<td>P = 0.13</td>
</tr>
</tbody>
</table>

In conclusion, Kory and colleagues recommend videolaryngoscopy as the first choice for less experienced providers performing an intubation in the ICU.

In overall summary these three studies, all examining different populations of patients indicate that the videolaryngoscopy provides superior first attempt success rates compared to the traditions direct laryngoscopy. All three also emphasize that there are group of patients ~10 to 20%, who cannot readily
be intubated with a videoscope, and in these patients the provider should be ready to revert to direct laryngoscopy.

6. Debate continues regarding the optimal resuscitation fluid; should chloride be avoided?


Young and co-investigators randomized adult trauma patients who were seriously injured to receive either intravenous infusion of 0.9% NaCl, or Plasma-Lyted, an isosmotic solution that contains much less Chloride. The patients were seriously injured and met the recruitment criteria of requiring blood transfusion, intubation or operation within 60 minutes of arrival at University of California Davis Medical Center. The baseline pH was 7.27 +/- 0.11 and the base excess was -5.9 +/- 5.0 mmol/L. In this small study of 46 patients, at 24 hours there was a difference in arterial pH and serum chloride.

<table>
<thead>
<tr>
<th></th>
<th>NS 0.9% NaCl  n = 24</th>
<th>Plasma-lyte  n = 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>39 +/- 14</td>
<td>38 +/- 19</td>
</tr>
<tr>
<td>ISS</td>
<td>22 +/- 14</td>
<td>24 +/- 18</td>
</tr>
<tr>
<td>Baseline; Base excess mmol/L</td>
<td>-6.4 +/- 4.7</td>
<td>-5.4 +/- 5.3</td>
</tr>
<tr>
<td>Baseline: pH</td>
<td>7.26 +/- 0.09</td>
<td>7.29 +/- 0.12</td>
</tr>
<tr>
<td>Baseline: Na</td>
<td>139 +/- 2</td>
<td>138 +/- 3</td>
</tr>
<tr>
<td>Baseline: Cl</td>
<td>107 +/- 4</td>
<td>106 +/- 4</td>
</tr>
<tr>
<td>Total Study fluids</td>
<td>9 +/- 5.5</td>
<td>10 +/- 6</td>
</tr>
<tr>
<td>At 24 hrs: Base excess mmol/L</td>
<td>-2.0 +/- 4.6</td>
<td>2.1 +/- 3.9</td>
</tr>
<tr>
<td>At 24 hrs: pH</td>
<td>7.37 +/- 0.07</td>
<td>7.41 +/- 0.06</td>
</tr>
<tr>
<td>At 24 hrs: Na</td>
<td>139 +/- 4</td>
<td>137 +/- 5</td>
</tr>
<tr>
<td>At 24 hrs: Cl</td>
<td>111 +/- 8</td>
<td>104 +/- 4</td>
</tr>
</tbody>
</table>

Conclusion; The infusion of Plasma-Lyte resulted in a more rapid and sustained clearance of base deficit and return to normal pH, without as much hyperchloremia.

**Association between a chloride-liberal vs chloride-restrictive intravenous fluid administration strategy and kidney injury in critically ill adults. *JAMA* 2012; 308: 1566-72**

The investigators compared two time periods; a control period where the standard intravenous fluid used was chloride rich (Normal saline), and then a later era when patients were infused with lactated solutions or a balance electrolyte solutions and chloride-poor Albumin. The patients were a wide range of critically ill adults treated in an ICU. The patients in the later time period, the “intervention period” were infused with less Chloride. The outcome, based upon sophisticated risk adjusted analyses, was that the patients given less chloride were less likely to have renal dysfunction and less likely to need renal replacement therapy. Mortality rates were not different.
Control period n = 760 | Intervention period n = 773

<table>
<thead>
<tr>
<th></th>
<th>Control period</th>
<th>Intervention period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>60</td>
<td>60.5</td>
</tr>
<tr>
<td>Post op patients</td>
<td>50%</td>
<td>49%</td>
</tr>
<tr>
<td>Chloride administration</td>
<td>694 mmol/patient</td>
<td>496 mmol/patient</td>
</tr>
<tr>
<td>Sodium administration</td>
<td>750 mmol/patient</td>
<td>623 mmol/patient</td>
</tr>
<tr>
<td>Serum creatinine increase</td>
<td>22.6 umol/L</td>
<td>15 umol/L</td>
</tr>
<tr>
<td>Renal injury/renal failure</td>
<td>14%</td>
<td>8.4% ( P = .005)</td>
</tr>
<tr>
<td>mortality</td>
<td>9%</td>
<td>8%</td>
</tr>
</tbody>
</table>

In summary the implementation of a policy of reducing chloride infusion into patients in an ICU needing resuscitation was associated with a reduction in renal dysfunction.


Shaw and colleagues analyzed a cohort of more than 30,000 surgical patients, and observed that in those infused with normal saline were more likely to require acute renal dialysis compared to those patients who were infused with Plasma-Lyte a solution with less chloride. The authors propose that infusion of a large load of chloride has detrimental renal outcome because of the renovascular effect of tubular chloride reabsorption. Greater Cl deliver to the macula densa region of the nephron may activate the tubule-glomerular feedback and trigger afferent arteriolar vasoconstriction, and thus reductions in glomerular filtration rate.

In conclusion, these three studies contribute to a growing body of recent data that infusion of balanced electrolyte solutions in which the majority of the anions are chloride increase the patients’ risk of complications, particularly a reduction in renal function. The action these observations call for is to stop using normal saline for resuscitation of patients, and instead depend on solutions such as Ringers lactate or one of the variations of Plasma lyte formulations which replace chloride with other organic anions.