Open Pelvic Fracture and Fecal Diversion

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Background: Mandatory fecal diversion has been advocated as an appropriate measure to prevent infection in the clinical setting of an open pelvic fracture. However, the efficacy of this practice has not been verified by prospective investigation and has received only inconsistent support from retrospective analyses.

Objective: To determine whether fecal diversion is associated with a substantially lower incidence of abdominopelvic infectious complications in patients with open pelvic fractures.

Design: Case-control study.

Setting: University-based tertiary care, level I trauma center.

Methods: The current study reviews our experience with 60 cases admitted from 1987 to 1993 to Harborview Medical Center, a regional level I trauma center. Data collected on each patient included age, sex, Injury Severity Score, Glasgow Coma Scale, initial heart rate and systolic blood pressure, location and severity of wound, fracture pattern, pelvic stability, time to open reduction internal fixation or external fixation, mortality, use of fecal diversion, and incidence and location of infection. Review of the literature produced an additional 186 patients amenable to analysis.

Results: Fecal diversion was performed in 19 patients, 5 (26%) of whom experienced subsequent abdominopelvic infectious morbidity. Of the remaining 41 patients, 7 patients (17%) experienced infectious complications. The 2 groups (diversion vs no diversion) were comparable with regard to relevant demographic and clinical characteristics of injury severity. Combining the present series with those reported by others gave a composite series of 246 patients. For the composite series, diversion was performed in 70% of patients. Infection developed in 27% of patients who underwent diversion vs 29% in patients who did not. In the present series, only mechanical instability was determined by stepwise logistic regression to be significantly associated with pelvic infection. This association was not altered by diversion status.

Conclusions: Diversion of the fecal stream to protect open pelvic fractures is not associated with a lower incidence of abdominopelvic infectious complications. Diversion may offer protection to a select group of patients with extensive soft tissue injury or posterior wounds. Mechanical instability was independently associated with infection.

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Divergence of the fecal stream is generally regarded as an integral component of minimizing the infectious morbidity and mortality associated with open pelvic fractures. The mortality of open pelvic fractures ranges from 6% to 70%, approximately 2 to 5 times the mortality of closed pelvic fractures. In 30% to 50% of cases, mortality is attributed primarily to the pelvic fracture, of which one third is related to development of sepsis from an infectious source in the pelvis.

The theoretical basis from which the practice of fecal diversion originates is based on the perceived risk of chronic fecal soilage of a wound, which, by definition, is in direct continuity with a pelvic fracture(s). The presence of a pelvic hematoma and devitalized tissue in close proximity to internally placed fracture-fixation hardware further heightens this concern. The experience with isolated rectal trauma in World War II and the Vietnam War, demonstrating decreased mortality with fecal diversion, has also influenced the management of open pelvic fractures. The modern tenet of early mobilization lends further theoretical support based on the unproven assumption that diversion protects internal hardware and promotes more rapid healing of wounds. However, while transmural rec-
SUBJECTS AND METHODS

Sixty consecutive cases of open pelvic fracture admitted from July 1987 to December 1993 to Harborview Medical Center in Seattle, Wash, a regional level I trauma center serving the northwestern United States, were reviewed. Cases were identified via the institutional trauma registry. Care in the field and the trauma center emergency department proceeded along Advanced Trauma Life Support guidelines (American College of Surgeons)\cite{1} with routine use of diagnostic peritoneal lavage and liberal use of pelvic angiography for those patients exhibiting hemodynamic instability and grossly normal findings on peritoneal lavage. Emphasis was placed on early pelvic fixation using either external fixation or definitive internal fixation at the earliest time permitted by the patient’s hemodynamic status and associated injuries. A retrograde urethrogram in the context of a suspected urethral injury and an endoscopic evaluation of the rectum were routine adjuncts to thorough physical examination. All wounds were aggressively debrided initially, with additional debridements performed on a daily or every other day schedule. A protocol for diversion, based on wound characteristics or injury severity, was not available; rather, the use of fecal diversion was individualized according to the preference of the attending trauma surgeon on call. All but 1 of the diverted patients underwent diversion within 48 hours of admission. Rectal washout was performed in the majority of diverted cases. However, absolute compliance could not be ascertained. Intravenous antibiotics were administered to all patients in the emergency department, with additional coverage provided on an individualized basis as indicated by microbiologic assessment.

The use of fecal diversion delineated the comparison groups: group 1, diversion; group 2, no diversion. The 2 groups were compared based on outcome variables and patient demographics. Data collected on each patient included age, sex, Injury Severity Score (ISS), Glasgow Coma Scale score (GCS), initial heart rate and systolic blood pressure, location and severity of wound, fracture pattern, pelvic stability, time to open reduction internal fixation or external fixation, use of fecal diversion, mortality, and infectious complications. A system by which to grade the degree of soft tissue injury associated with open pelvic fractures does not currently exist. The Gustilo system, originally described for long bone fractures and heretofore not applied to pelvic fractures, was used in this study to facilitate the evaluation of a potential association of infection with the degree of soft tissue injury. Wounds were assigned a Gustilo grade I to III according to the following criteria:\cite{2}, grade I, low-energy wounds (small laceration or puncture of the skin) without tissue loss or evidence of crushing; grade II, higher-energy wounds with a less than 10-cm injury zone, usually with minimal soft tissue loss and contusion and contamination of wound edges; and grade III, very-high-energy wounds with a greater than 10-cm injury zone, associated with marked displacement and comminution of bone as well as loss of soft tissue. The incidence of abdominopelvic infectious complications was then determined for each group. Infection was diagnosed by the surgical team and was based on the results of physical and radiographic examination combined with Gram stain and culture of purulent wounds or drained fluid collections. Only abdominal and pelvic sites were considered in this study.

Review of the literature produced an additional 186 patients for whom information about diversion and infection was available. The literature series was combined with our series to generate a composite group of patients for analysis of diversion and infection.

Statistical analysis was based on the 2-tailed t test, and \( \chi^2 \) analysis with Yates correction where appropriate. \( \chi^2 \) Test for trend and logistic regression were used to assess potential trends and evaluate for interaction and the presence of confounding variables. Stepwise logistic regression was performed to identify variables associated with specific outcome measures. Variables assessed included ISS, GCS, pelvic stability and fracture pattern, and wound location and severity. \( P \) values < .05 were considered significant. Statistical analysis was performed using SPSS for Windows 6.0 (SPSS Inc, Chicago, Ill.).

RESULTS

Demographic and clinical data are shown in Table 1. There was no significant difference between the diverted and nondiverted groups with respect to age, sex, ISS, GCS score, initial vital signs, time to emergency department, or time to skeletal fixation. Table 2 presents the distribution of injury mechanisms. Table 3 and Table 4 compare fracture and wound characteristics for the 2 study groups. There was no significant difference in the distribution of fracture patterns, fracture stability, wound location, or wound severity between the diverted and nondiverted groups. \( \chi^2 \) Test for trend (Mantel-Haenszel) for diversion and Gustilo grade produced a \( P \) value of .08. Although statistically insignificant, this result suggests selection for diversion was not completely arbitrary and may have been influenced by the perceived magnitude of soft tissue damage.

Fecal diversion was performed in 19 patients (group 1). Five diverted patients (27%) experienced abdominopelvic infectious complications; 7 (17%) of 41 nondiverted patients experienced infectious complications (Table 5). The specific infectious complications and associated microorganisms are presented in Table 6. The incidence of infection between groups remained statics-
tically insignificant after logistic regression and controlling for ISS, GCS scores, initial vital signs, pelvic injury pattern and severity, and time to skeletal fixation (relative risk is shown in Table 5).

Stepwise logistic regression and \( \chi^2 \) test for trend identified mechanical instability, as determined by findings on physical examination, as the only variable associated with infection. \( P \) values were .01 (stepwise logistic regression) and .004 (\( \chi^2 \) test for trend). However, diversion status had minimal effect on this statistical relationship. A Tile C fracture was likewise associated with infection (by animal or heavy equipment) to accidents with power boats and large turbines.

Other analysis was performed for all data amenable to stratification by location. The results are presented in Table 7. For wounds of the groin, flank, or lower abdominal wall, infection developed in 4 (27%) of 15 diverted patients vs 4 (11%) of 35 nondiverted patients. For wounds of the perineum, infection occurred in 17 (40%) of 42 diverted patients vs 5 (26%) of 19 nondiverted patients. For wounds of the anus, the corresponding figures are 2 (20%) of 10 diverted patients vs 1 (20%) of 5 nondiverted patients; and those for the buttock region are 2 (18%) of 11 diverted cases vs 6 (43%) of 14 nondiverted cases. Due to insufficient information, these cases could not be stratified according to wound severity.

The open pelvic fracture is a complex injury pattern with potentially significant morbidity and mortality. Hemorrhage and associated injuries account for the majority of deaths in the first 48 hours. However, infectious complications contribute to as many as 50% of late deaths, accounting for a significant proportion of overall mortality. \(^1,3,5\) Measures to improve outcome have therefore
focused not only on early definitive control of hemorrhage but also on the prevention of infection. It has been assumed that diversion of the fecal stream from a massively traumatized pelvis would lower the incidence of subsequent infectious morbidity and mortality. Retrospectively evaluated success, based on small numbers of patients, perhaps provided the basis from which has emerged a modern tendency to divert fecal flow in the vast majority of cases of open pelvic fractures, regardless of wound location and severity. The analysis of the composite series presented confirms this tendency; 70% of patients underwent diverting colostomy. While the efficacy of diverting full-thickness lacerations of the rectum is accepted, it should be understood that the management of such wounds is a priori excluded as a focus of this study and discussion.

Several retrospectively evaluated series of open pelvic fractures offer statements on the utility of fecal diversion.\textsuperscript{4-8,13-18} In the majority of reports, diversion is a peripheral topic, and location and severity of wounds are either not specifically described or not correlated with subsequent infectious morbidity. Perry\textsuperscript{4} recommends diversion for all patients with wounds of the perineum, vagina, or rectum communicating with the fracture. His report of 31 patients, however, does not specify the actual number of patients who underwent diversion or the relationship of diversion to the 10 cases in which septic complications occurred. Maull et al\textsuperscript{13} reported a series of 12 cases in 1977, in 9 of which the patients received a colostomy. Of those so treated, 3 developed infectious complications. Likewise, 1 of the 3 nondiverted patients experienced an infectious complication. Maull et al that all patients should receive a diverting colostomy with distal washout. In 1991, Latenser et al\textsuperscript{17} reported results of early fixation in mechanically unstable fractures. This series contained 7 cases of open pelvic fractures. All of the 4 nondiverted patients experienced infectious complications; the 3 diverted patients had no infectious problems. The nondiverted patients were in the historic control group in which early fixation was not performed. Surprisingly, this article provided no explicit comment on the utility of diversion. Osterlee et al\textsuperscript{13} explicitly endorsed diversion in their report of 8 patients, all of whom had been run over by heavy vehicles. One of the 7 diverted patients experienced infectious problems vs no infection for the 1 nondiverted patient. Inspection of the results of these series fails to disclose an important relationship of diversion and infection.

There are a small number of reports that do relate outcome to wound location or severity. In 1967, Froman and Stein\textsuperscript{2} reported a series of 75 cases of severe pelvic trauma, 12 of which sustained injury to the anus or rectum. Of the 9 patients treated with diversion, 2 experienced infectious complications; none of the 3 nondiverted patients suffered infectious morbidity. Raffa and Christensen\textsuperscript{2} reported their 10-year experience (1965-1975) with 16 patients treated at San Francisco General Hospital. Eight patients with extensive wounds of the perineum or rectum underwent diversion; infectious complications developed in 6 patients. Infectious problems developed in only 4 of the 8 nondiverted patients, in whom wounds were located in the gluteal region (3), vagina (1), and perineum (1) [parenthetic numbers are as given in cited reference and did not add up to 8]. The series of 37 patients reported in 1982 by Richardson et al\textsuperscript{8} contains the lowest currently published mortality of 5%. Twenty-six patients underwent diversion. Regardless of diversion, no patient with an anterior wound (abdominal wall or groin) experi-

### Table 5. Infection and Mortality in Groups 1 and 2\textsuperscript{*}

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Group 1: Diversion</th>
<th>Group 2: No Diversion</th>
<th>RR†</th>
<th>P‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>5 (26)</td>
<td>7 (17)</td>
<td>1.56</td>
<td>.41</td>
</tr>
<tr>
<td>Mortality</td>
<td>2 (11)</td>
<td>5 (12)</td>
<td>0.82</td>
<td>.85</td>
</tr>
</tbody>
</table>

*Values are expressed as number (percentage). †Relative risk (RR) for colostomy group compared with noncolostomy group. ‡P values were obtained by χ² analysis.

### Table 6. Infectious Complications in Groups 1 and 2

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Case Description*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pelvic abscess; Gustilo grade II of groin, rectum; Enterobacter</td>
</tr>
<tr>
<td>2</td>
<td>Wound infection; Gustilo grade III of flank and buttock; \textit{Bacteroides}</td>
</tr>
<tr>
<td>3</td>
<td>Pelvic abscess; Gustilo grade III of RLQ (eviscerated bowel); organism not known</td>
</tr>
<tr>
<td>4</td>
<td>Operative wound infection (groin); Gustilo grade III of perineum; \textit{Pseudomonas}</td>
</tr>
<tr>
<td>5</td>
<td>Thigh abscess; Gustilo grade III of buttock and perineum; \textit{Pseudomonas}</td>
</tr>
<tr>
<td>6</td>
<td>Wound infection; Gustilo grade III of RLQ, groin, thigh; \textit{Pseudomonas}</td>
</tr>
<tr>
<td>7</td>
<td>Wound infection; Gustilo grade II of groin, thigh; \textit{Bacteroides}</td>
</tr>
<tr>
<td>8</td>
<td>Wound infection; Gustilo grade I of RLQ; Enterobacter</td>
</tr>
<tr>
<td>9</td>
<td>Wound infection; Gustilo grade III of buttock; \textit{S aureus}</td>
</tr>
<tr>
<td>10</td>
<td>Pelvic abscess; Gustilo grade II of perineum; organism not known</td>
</tr>
<tr>
<td>11</td>
<td>Wound infection; Gustilo grade I of groin; organism not known</td>
</tr>
<tr>
<td>12</td>
<td>Thigh abscess; Gustilo grade I of perineum; \textit{Escherichia coli}</td>
</tr>
</tbody>
</table>

*RLO indicates right lower quadrant.

### Table 7. Site-Specific Infectious Outcome for the Composite Series\textsuperscript{*}

<table>
<thead>
<tr>
<th>Location</th>
<th>Group 1: Diversion</th>
<th>Group 2: No Diversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>4/15 (26)</td>
<td>4/35 (11)</td>
</tr>
<tr>
<td>Perineum</td>
<td>17/42 (40)</td>
<td>5/19 (27)</td>
</tr>
<tr>
<td>Perianal</td>
<td>2/10 (20)</td>
<td>1/5 (20)</td>
</tr>
<tr>
<td>Buttock</td>
<td>2/11 (18)</td>
<td>6/14 (43)</td>
</tr>
</tbody>
</table>

*Values are expressed as number/number (percentage). Percentage refers to the percentage of patients with infection in the group at risk for each location of wound.
enced an infectious complication. For buttock wounds, none of the 5 diverted patients, vs 2 of 3 nondverted patients experienced infection. Regarding wounds of the perineum, 7 (43%) of 17 diverted patients vs all 3 nondverted patients, experienced infection. Based on these results, Richardson et al endorse early diversion of all cases with wounds of the buttock or perineum. The primary caveat of their study is the lack of injury severity rating. The text does offer descriptions of the injuries of a limited number of patients, suggesting the entire group exhibited the usual patterns of injury associated with open pelvic fractures. Faringer et al presented a series of 31 patients. One of 3 diverted patients with wounds of the lateral pelvis or groin crease experienced wound sepsis; 1 of 11 nondverted patients with similarly located wounds experienced wound sepsis. Regarding wounds of the perineum, 4 (36%) of 11 diverted patients vs none of the 4 nondverted patients experienced wound sepsis. Faringer et al conclude that selected patients do not require diversion.

Given the prevailing lack of a study that prospectively randomizes sufficient numbers of similarly injured patients, reliable indications for diversion have not been available. Our study evaluates a rather large number of patients; nevertheless, the lack of prospectivity warrants caution in the interpretation of the data.

Our data indicate that diversion in patients with open pelvic fractures is not associated with a lower incidence of abdominopelvic infectious complications. This finding is further substantiated by the analysis of the composite series, in which the incidence of infection in the diverted and nondverted groups was nearly identical. This surprising result demands explanation. Two counterposed arguments may be presented: (1) for the majority of patients, diversion prevents infection, and all patients needing diversion were correctly identified and diverted or (2) in the majority of cases, infection is initiated by an inoculum introduced at the time of injury and is not considerably influenced by diversion. The lack of a historic consensus on criteria selecting patients for diversion is inconsistent with the first explanation. If, however, the latter explanation were true, diversion would be a mere epiphenomenon, and an analysis of a sufficiently large number of cases would reveal similar incidences of infection—consistent with the results of the composite series.

Although statistically nonsignificant, the trend between Gustilo grade and diversion merits further discussion. It is possible that a much larger study would have revealed a significant trend, suggesting a potentially inherent bias in the selection of patients for diversion. Our data failed to reveal a trend between infection and Gustilo grade (P = .64, \( \chi^2 \) test for trend); moreover, this lack of association was not affected by diversion status. For the diverted group, 4 (40%) of 10 Gustilo grade III cases experienced an infectious complication compared with 2 (14%) of 14 Gustilo grade III cases in the nondverted group. Unfortunately, the absolute number of infections, when distributed among all possible 6 categories, is too small for a definitive conclusion to be made. The available data, however, do not support the argument that selection bias obscured a statistically significant benefit of diversion.

Mechanical instability was the only variable with a statistically significant association with infection. In fact, a mechanically unstable pelvis, as determined by physical examination, was associated with a 10-fold increased risk of infection. The association was not altered significantly by diversion status, ISS, or time to open reduction internal fixation. This result suggests the relevance of the magnitude of energy dissipated into the pelvis and the probable degree of associated soft tissue devitalization. That diversion or time to open reduction internal fixation had minimal effect lends further support to the notion that infection is determined primarily by an inoculum introduced at the time of injury.

The results relating incidence of infection to location of wound warrant further investigation. For buttock wounds, diversion is associated with a somewhat lower incidence of infection. This is perhaps noteworthy, as disruption of the skin producing a buttock wound in the presence of a pelvic fracture may be a surrogate marker of a pelvis subjected to greater energy transmitted through the rectosigmoid and a substantial amount of soft tissue. Such wounds may therefore harbor a greater degree of devitalized underlying soft tissue, as well as perhaps an occult injury to the rectosigmoid. It may also reflect the greater difficulty of care of posterior wounds in a supine patient. Although not statistically significant by current data, the trends document that diversion may be beneficial in this specific subgroup of patients.

Last, diversion should not be regarded as an intervention without morbidity. For example, opening the abdomen promotes increased pelvic volume and therefore a risk of exacerbating hemorrhage. Likewise, opening the abdomen and the colon introduces further contamination of what otherwise may have been a relatively uncontaminated abdomen. In addition, a functioning stoma juxtaposed to abdominal and groin wounds may actually enhance their contamination and risk of infection. Moreover, diversion implies subsequent restoration of continuity, a procedure associated with a substantial complication rate. Finally, diversion incurs the additional financial cost of 2 surgical procedures with unproven benefit in the majority of patients.

CONCLUSIONS

Results of our review of 60 cases of open pelvic fracture and interpretation of the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that the available literature do not support the contention that
complications. Although not proven, the trends in infection with location of wound support consideration for increased use of diversion for buttock wounds only. Further investigation with a larger number of patients is needed to verify this finding, as well as to perhaps identify other subgroups for whom diversion would be beneficial.

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REFERENCES