Feasibility of Damage Control Surgery in the Management of Military Combat Casualties

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Unique and expanded applications of staged operative management are undergoing careful evaluation in many civilian level I trauma centers under the rubric of damage control surgery. Recently there have been advocates for its broad application to the early management of critically injured combat casualties. However, the enormous logistic requirements for such strategies are contrary to the demands of the usual wartime scenario. On the basis of experience in civilian trauma centers and combat casualty management, we question the suggested extensive role of damage control surgery during wartime. Each decision point in damage control surgery should be analyzed as it is altered (sensitivity analysis) by conditions of war. It is unwise to adopt such indications unchanged from current civilian trauma policy.

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Military surgeons must decide how best to apply evolving civilian trauma management techniques to the harsh logistic environment of future wars. This usually requires compromise of the new clinical methods as practiced in civilian trauma surgery for use in the evolving technologies of war.1,2

This article concerns which aspects of damage control surgical (DCS) policies currently under trial in the civilian trauma community are feasible in the early care of seriously injured combat casualties after major abdominal trauma. Because DCS is highly personnel and technology dependent, these features are emphasized because they are limited in a combat scenario.

DEFINITION OF DCS AFTER TRAUMA

The term “damage control” has recently been applied to a variety of staged techniques in the early care of the severely injured.3-7 Temporary operative procedures provide time for physiologic stabilization of the patient before subsequent definitive operative repair. This is a logical extension of staged operative management of the severely injured that has been used for many years in civilian and military trauma surgery. With improved transportation of the injured, staged care has achieved added importance because many patients who died before hospitalization now are kept alive to reach a civilian or forward military trauma center.

See Invited Critique at end of article

Damage control is a traditional Navy term.8,9 It refers to keeping a badly damaged ship afloat after major penetrating injury to the hull. Procedures for temporary righting and stabilizing the ship classically involved stuffing mattresses into gaping holes in the ship’s hull, extinguishing local fires to prevent spread of the inflammation, and “dogging down” watertight doors to limit flooding and spread of damage. This provides time for the ship to be righted using judicious addition of water (counterflooding) to counter a dangerous list. Other measures are used to isolate the fires and explosions at the point of injury and prevent damage from spreading. These measures, which keep the ship afloat, permit assessment of other damage and time to establish a sensible plan.
for definitive repair. The analogy to care of the seriously injured is obvious.

**DCS AFTER ABDOMINAL TRAUMA**

The customary indications for embarking on DCS in a civilian environment is in a severely injured patient who does not respond to the usual methods of resuscitation and seems to be dying unless extraordinary operative means can be used to turn the tide of events. Trauma surgeons are familiar with the poor outcome expectancy of undertaking prolonged surgery on such physiologically unstable patients. Many such patients are hypothermic and die of uncontrolled early bleeding or subsequent multiple organ failure.10

Damage control surgery is intended to alter this disastrous clinical course. Early abbreviated laparotomy is performed on the partially resuscitated patient to stop life-threatening hemorrhage and to minimize further major peritoneal soiling. The abdomen is closed by swift and physiologic stability. The interval between the initial abbreviated surgery and subsequent definitive operative repair might be as short as 30 minutes or require several hours of intense rewarming and stabilization

(Figure 2). During this period there are enormous requirements for skilled personnel and high-technology support. Those making military medical policies—many of whom are neither physicians nor surgeons—must understand these uncompromising demands if they plan to use DCS policies in future conflicts.

**OPERATIVE PROCEDURES IN DCS**

Some operative techniques used at laparotomy for temporary damage control are temporary packing to control diffuse bleeding from the liver, spleen, pelvic, or retroperitoneal surface; occasional use of a temporary intravascular shunt; and even ligation of a critical artery (Table 1). Segments of diffusely damaged gastrointestinal tract might be isolated with staples or even tapes, leaving blind loops of intestine until they can be removed or repaired at the subsequent definitive surgery. The laparotomy wound usually is temporarily closed by one of several quick techniques, some of which have unique equipment requirements. For example, wound closure with towel clips requires more such clamps than usually are available in a forward area military issue surgical pack. Quick closure can also be achieved using largecaliber sutures through the skin. To avoid the adverse effects of elevated intraperitoneal pressure (abdominal compartment syndrome11), however, the abdominal wound usually should be left open, with coverage of the viscera using one of several available materials.3

**MONITORING AFTER INITIAL LAPAROTOMY**

The decision for the optimum moment to reoperate requires clinical skill and experience. The trauma surgeon must synthesize observation of the patient with a variety of high-technology laboratory monitoring data (Figure 3). Hypothermia and its consequent coagulopathies must be corrected. However, core temperature alone cannot dictate timing for subsequent surgery. An important current challenge is to find laboratory studies that best indicate timing of subsequent surgery, ie, when benefits of delay, rewarming, and resuscitation no longer exceed the progressive harm caused by damaging factors such as continued bleeding, incompletely closed holes or blind loops of bowel, or ischemic tissue within the peritoneal cavity. The moment is fleeting and difficult to identify. The relation between benefits and detriments of delay is illustrated in Figure 4. Table 2 lists monitoring techniques and laboratory and imaging
studies often performed on patients after DCS and before subsequent surgery for definitive repair. Personnel typically required to perform these studies and interpret their results during the interoperative period include trauma surgeons, anesthesiologists, clinical laboratory personnel, blood bank personnel, respiratory therapists, pharmacy and central supply personnel, the operating room nursing team, and the intensive care unit nursing team. An enormous resource commitment is inherent in proper performance of DCS.

TIME BETWEEN INITIAL AND DEFINITIVE SURGERY

The time between closure of the initial DCS (“fast surgery”) and subsequent surgery for definitive repair might be as short as 30 minutes, in which case the patient usually is kept in the operating room, making the room unavailable for use in the management of other casualties. This might be acceptable in a civilian trauma center, where the number of casualties is usually limited and many other operating rooms are available and other patients are not being denied operative care. This is rarely the case in a forward military facility, where benefits to one severely injured patient who has a high probability of dying must be balanced against the benefits to many others with lesser injuries. On the other hand, premature return to the operating room without optimal resuscitation might be lethal (Figure 5). Time between closure of the fast surgery laparotomy and subsequent surgery for definitive repair at the Denver Health Medical Center in Denver, Colo, between January 1, 1998, and January 1, 1999, is grouped as follows:

<table>
<thead>
<tr>
<th>Time, h</th>
<th>Patients, %</th>
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<tbody>
<tr>
<td>0-4</td>
<td>0</td>
</tr>
<tr>
<td>&gt;4-6</td>
<td>6</td>
</tr>
<tr>
<td>&gt;6-12</td>
<td>38</td>
</tr>
<tr>
<td>&gt;12-24</td>
<td>32</td>
</tr>
<tr>
<td>&gt;24-48</td>
<td>12</td>
</tr>
<tr>
<td>&gt;48-72</td>
<td>12</td>
</tr>
<tr>
<td>&gt;72</td>
<td>0</td>
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</tbody>
</table>

Figure 3. Identifying the “fleeting moment” for subsequent surgery demands the synthesis of high-technology laboratory test results and close observation of the patient. DCS indicates damage control surgery.

Figure 4. The risk-benefit of timing between damage control surgery (DCS) and subsequent surgery for definitive repair. An inappropriate delay might result in a lethal complication.

Figure 5. Premature subsequent surgery before optimal hemodynamic status and correction of coagulation function are achieved might result in intraoperative death. DCS indicates damage control surgery; MOF, multiple organ failure.
SURVIVAL AFTER DCS

Medical decisions and policy require comparing outcome expectancies of competitive management options. Damage control surgery is undertaken only on severely injured patients who are considered to be dying unless heroic measures can be provided. Under these circumstances, the trauma surgeon is haunted by the specter of indulging in futile care. This is of particular importance in a military environment, where many other patients with a better prognosis for survival are competing for care, when further care to one patient reduces available help for many others.

The problem is compounded because there is no reliable outcome expectancy data correlating benefit of specific indications or techniques used in DCS (fast surgery) with survival. The best available noncomparative data are summarized in Table 3. Many trauma surgeons can recall patients who survived temporary packing to control diffuse bleeding, but at the other extreme no one has data concerning survival after temporary ligation or shunting of critical arteries or veins in such hypotensive, hypothermic, and severely injured patients. Gathering such data is challenging to the current civilian trauma community. Until it becomes available, military policy makers must provide guidelines based only on popular informed belief and practice. The following guidelines seem reasonable, but they will change as more evidence accumulates.

GUIDELINES FOR USE OF DCS TECHNIQUES IN FORWARD MILITARY SURGICAL FACILITIES

Military surgeons and policy makers should become familiar with the principal indications, techniques, and accumulating outcome data of DCS in civilian trauma centers. Clinically active young trauma surgeons within their military corps should be designated as advisors for this purpose. Their recommendations, based on civilian experience, should be reviewed by medical officers who have personal experience in the practical constraints of surgery in time of war. Casualties in future wars will differ in many ways from those in 20th-century wars. All indications are that there will be more civilian than military personal among the injured. If the pattern continues as in recent years, most of the injured will be provided surgical care in a wide variety of civilian hospitals, not in military facilities. Inevitably, many of the community surgeons will, at least in the opening stages of war, be unfamiliar with early operative care of the injured. Neither will their community hospitals be equipped to provide the many support services necessary for use of DCS. As in the past, plans should be based on a future scenario, not on what existed in the past.

Currently, hypothermia, coagulopathy, and acidosis are justifiably being demonized as major culprits in resistance to resuscitation after major trauma. Their arrest will be a major objective in restoring order to many wartime casualties.

Forward surgeons, many of whom are inexperienced in trauma surgery, should consider the following factors before embarking on 1 or more operative techniques of DCS in a seriously injured casualty: (1) outcome expectancy of the patient considering all of the wounds, the delay in resuscitation, the level of support provided, and the response to resuscitation; (2) the number and nature of other casualties awaiting care; (3) personnel, supplies, and equipment available and necessarily committed once the decision is made to undertake DCS; (4) the military situation, ie, the feasibility of making the requisite intense professional monitoring observation and time-constrained decision to reoperate after initial fast surgery; and (5) after fast surgery, will a single team be available to make the incision and perform the definitive care, correcting temporary measures performed at the initial surgery? What are the realistic delays in the casualty evacuation and transportation chain?

### Table 3. Survival for Damage Control Surgery in Civilian Trauma Centers

<table>
<thead>
<tr>
<th>Study and Year</th>
<th>Institution</th>
<th>Mortality, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burch et al, 1992</td>
<td>Ben Taub General Hospital, Houston, Tex</td>
<td>134/200 (67)</td>
</tr>
<tr>
<td>Morris et al, 1993</td>
<td>Vanderbilt University, Nashville, Tenn</td>
<td>64/107 (60)</td>
</tr>
<tr>
<td>Rotondo et al, 1993</td>
<td>Hospital of the University of Pennsylvania, Philadelphia</td>
<td>0/24 (0)</td>
</tr>
<tr>
<td>Garrison et al, 1996</td>
<td>University of Louisville (Ky) School of Medicine</td>
<td>47/70 (67)</td>
</tr>
<tr>
<td>Cosgriff et al, 1997</td>
<td>Denver ( Colo) Health Medical Center</td>
<td>6/18 (33)</td>
</tr>
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</table>
experience for advice in selecting patients for such management. We must acknowledge that these evolving techniques are based on an incomplete outcome expectancy database.

**CONCLUSIONS**

Damage control surgery is an emerging surgical concept in early management of the severely injured that deserves the serious attention of military medical planners. Although there are as yet insufficient data to determine its clinical efficacy in increasing survival, those responsible for early care of the military casualty should be familiar with its techniques. Some details of the technique, such as rewarming, deserve special emphasis.

Damage control surgical techniques inevitably require an enormous logistic commitment, which rarely will be available under conditions of war. Largely, for this reason, DCS will be impractical for common use in a forward military unit during times of war.

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**Invited Critique**

It is evident from the analysis by Eiseman et al that DCS provides a challenge and an opportunity for conventional planners on how to allocate resources when, predictably, clinical needs exceed available resources. Damage control surgery, although conceptually new, actually uses well-tested surgical approaches in a more abbreviated context. The operative emphasis is on stopping hemorrhage and controlling ongoing contamination; the physiologic emphasis is on restoring body temperature, normal coagulation, and acid-base balance. The challenge to the surgeon who first encounters the wounded patient is to defer from providing definitive repair. It is the initial surgeon’s role to keep the context abbreviated. The challenge to the system is to quickly transport the critically injured casualty to a secondary facility for critical care and definitive surgery.

The authors may have overstressed the obstacles to DCS at the forward surgical units and underestimated the logistical issues necessary to ensure timely evacuation and provision of supportive and definitive management at backup facilities. The obvious advantage for the planner and most patients is the flexible but limited time window models that exist to perform DCS and to transfer patients to a higher level of care. To do less in the combat situation is to abandon potentially salvageable combat casualties to their otherwise certain fate.

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**REFERENCES**