Incisions made with a carbon dioxide (CO₂) laser are variously reported to be less bloody, less painful, and less prone to seroma formation and to heal better than scalpel or electrosurgical incisions.¹⁻⁸ These claims are based largely on nonrandomized studies, however, and are contradicted by other studies showing no advantage of CO₂ laser incisions.⁹⁻¹⁹ This study was undertaken in an attempt to clarify this issue. If the proposed benefits of this laser could be confirmed, considerable reduction in postoperative patient discomfort and reduced cost of treating postoperative pain might result from more widespread use of the modality.

**MATERIALS AND METHODS**

The clinical treatment model was uncomplicated elective cholecystectomy. Patients with significant coexisting morbid conditions such as heart disease, stroke, pancreatitis, hematologic disorder, or history of drug abuse were excluded from the study. Those with known bile common duct stones before surgery and those who underwent an unplanned common bile duct exploration were also excluded since the increased time of their operation might have increased chances of wound infection. Laser malfunction was the final criterion for exclusion.

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From the Department of Surgery, University of Colorado Health Sciences Center, Denver, and Denver Veterans Affairs Hospital.
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Reprint requests to Department of Surgery, University Hospital, 4200 E Ninth Ave, Denver, CO 80262 (Dr Pearlman).
ended to methods used for each patient's incision asked him or her to rate pain during the preceding 24 hours on a pain analogue scale of 0 to 10 where 0 indicates "no pain" and 10, "worst pain ever." The total score for the first 3 days after surgery was defined "subjective pain." Patients discharged before 3 days were con-
tacted at home by the nurse to complete this evaluation. "Ob-
tive pain" was defined as the total number of intramuscular narcotic injections for the first 3 days. The nurse also examined incisions daily and recorded any wound seromas or infections during hospitalization and at 7 days' follow-up.

Treatment methods were evaluated for differences in incision type, incision blood loss, subjective and objective pain, and seromas/infections with one-way analysis of variance, and compared using Newman-Keuls tests at P < .05. To account for differences in operating time/technique between surgeons and variability in patient appreciation of pain, only differences in mean values of 25% or greater were considered clinically significant. Results were rounded to the nearest whole number to simplify presentation.

RESULTS
Between July 1987 and October 1989, 100 patients en-
rolled in the study. Twelve were later excluded because of
er unplanned common bile duct exploration (n = 10) or other malfunction (n = 2). Distribution of the remaining pa-
tients by cohort and group characteristics is shown in Ta-
ble 1. Mean age and sex distributions were similar between
cohorts. Patients receiving laser or electrosurgical incisions
tended to be older and weighed somewhat greater than those receiving scalpel incisions, but the differences were not statistically significant.

All but one patient (who underwent electrosurgery) had incision seroma. Ten patients received antibiotics after surgery because of bile spillage during gallbladder re-

cought, and two lasing-scalpel patients). Other results are pr

Table 1.—Patient Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Laser</th>
<th>Scalpel</th>
<th>Electrosurgery</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>32/26</td>
<td>36/13</td>
<td>3/27</td>
<td></td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>39±13</td>
<td>37±14</td>
<td>36±13</td>
<td>NS</td>
</tr>
<tr>
<td>Age, y</td>
<td>65±15</td>
<td>58±9</td>
<td>63±13</td>
<td>NS</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>63±15</td>
<td>58±9</td>
<td>63±13</td>
<td>NS</td>
</tr>
</tbody>
</table>

SDs. NS

All but one patient (who underwent electrosurgery) had incision seroma. Ten patients received antibiotics after surgery because of bile spillage during gallbladder re-

cought, and two lasing-scalpel patients). Other results are pr

Table 2.—Comparison of Incision Time (IT), Incision Blood Loss (IBL), Subjective Pain (SP), Objective Pain (OP), and Wound Seromas/Infections (WS/I) Among the Three Treatment Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Laser</th>
<th>Scalpel</th>
<th>Electrosurgery</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT, min</td>
<td>12±4</td>
<td>9±5</td>
<td>7±3</td>
<td>&lt;.05†</td>
</tr>
<tr>
<td>IBL, mL</td>
<td>31±26</td>
<td>31±22</td>
<td>13±8</td>
<td>&lt;.05‡</td>
</tr>
<tr>
<td>SP</td>
<td>15±5</td>
<td>18±6</td>
<td>16±4</td>
<td>NS</td>
</tr>
<tr>
<td>WS/I</td>
<td>8±4</td>
<td>9±4</td>
<td>8±3</td>
<td>NS</td>
</tr>
</tbody>
</table>

No. of WS/I  0  NS

*All values except for the number of wound seromas/infections are means±SDs.
†Electrosurgery vs laser and scalpel vs laser.
‡Electrosurgery vs scalpel and laser.

and lymphatics up to 0.5 mm in diameter.9,10 It has been suggested that the laser will seal transected nerves at the edge of the wound as well.1 When the laser is defocused, less violent heating of tissue occurs, and this can often be used to control blood vessels up to 2 mm in diameter.9,10 The following characteristics seem to make the CO2 laser ideal for making incisions: precise cuts, less blood loss than with a scalpel, and less deep tissue injury than with electrosurgery. In some studies, this promise of improved incisions seems to have been fulfilled. When the CO2 laser was used to excise intracranial lesions and the wound bed was left open, less postoperative pain than expected and prompt healing have been reported.11,12 Flor and Banez9 compared CO2 laser and scalpel incisions for elective colec-
tomy in a randomized study and found less pain with the former. Ansanelli5 and Wang6 carried out retrospective comparisons of CO2 laser and scalpel mastectomies, concluding that blood loss and seroma formation were re-

in the study by Basu et al. Filmar and coworkers17 did find that histologic damage in rat uterus was greater after electrosurgical incision than after CO2 laser incision, but both types of wound healed at the same rate. The studies by Stern and Lucente18 and Apfelberg et al19 discerned no reduction in the historical rate of keloid recurrence with the CO2 laser excision compared with the scalpel excision.

COMMENT

The CO2 laser is almost completely absorbed in cellular water, and when focused to a spot size of 0.5 mm or less results in flash boiling and vaporization of ar elements.9,10 Thermal damage beyond the edge of the wound is limited to a narrow band of tissue less than 1 mm in width, but is often enough to seal blood vessels

Laser, Scalpel, and Electrosurgery—Pearlman et al 1019
In the present study, use of the CO₂ laser led to greater time and blood loss for a standard incision, but the differences were relatively small and probably not meaningful in an operational sense, even though they did meet preset criteria. There was a slight (three-point) reduction in mean subjective pain after laser incisions compared with scalpel incisions. This difference might have been statistically significant (P<.05) if the sample size had been as large as originally planned (53, 53, and 34 patients in each group) and sample variance remained the same, but would still have failed to reach clinical significance (mean difference of 25%, or 3.7 points). Finally, there was no difference between the laser-treated group and the scalpel- or electrosurgery-treated groups in objective pain or wound seromas/infections. Although the incidence of wound complications was low (three [3.4%] of 88 patients), the numbers reflect unbiased observations by the study nurse and may be the result of methods used for patient selection.

It appears that many incisions cause enough pain and/or tissue damage to overshadow any theoretic advantage the laser might offer. A similar argument might be made in regard to any putative sealing of transected nerve endings with the laser. In the absence of other findings, it is difficult to conclude that the CO₂ laser offers any real advantage over conventional methods of making incisions.

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References
14. Hambley R, Habda PA, Abell E, Cohen BA, Jegasothy BV. Wound healing of skin incisions produced by ultrasonically vi-