Clinical and economic consequences of early discharge of patients following supratentorial stereotactic brain biopsy


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Objective. The goal of this study was to determine the clinical and economic consequences of early discharge (<8 hours) of patients following stereotactic brain biopsy (SBB).

Methods. The records of all patients who underwent percutaneous SBB at The Cleveland Clinic Foundation, a tertiary care teaching hospital, during 1994 and 1995 (Group A) were retrospectively reviewed to collect data on the nature and timing of perioperative (<48 hours) clinical and radiological complications. Biopsies were performed using image-guided stereotaxy either with or without a frame. Based on the results, guidelines for early discharge of patients following SBB were implemented. Information on the nature and timing of perioperative complications was also collected prospectively in all patients who underwent percutaneous SBB from January 1996 through July 1998 (Group B). Hospital financial records for patients who underwent SBB in 1997 and 1998 were also reviewed and assessed for net revenue stratified by discharge status: early discharge (<8 hours), extended outpatient observation (8–24 hours), and inpatient hospitalization (≥24 hours).

In Group A, 130 biopsies were performed. There were five serious complications (3.8%), of which four were transient, and there was one death (0.8%). The death and any sustained deficit occurred in patients in whom a clot had been demonstrated on postoperative CT scans. All complications were detected within 6 hours after surgery. Intraoperative bleeding occurred in 12 patients (9.2%), but was associated with only 40% of cases in which hemorrhage appeared on postoperative CT scans. Guidelines for early discharge (<8 hours) following SBB were developed and stipulated the absence of the following: 1) intraoperative hemorrhage; 2) new postoperative deficit; and 3) clot on a postoperative CT scan.

In Group B, 139 biopsies were performed. There were three serious complications (2.2%), one of which was sustained due to a clot that had been demonstrated on the postoperative CT scan. All complications were detected within 6 hours post-surgery. There were no deaths in this group. Intraoperative bleeding occurred in 11 patients (7.9%), requiring intraoperative craniotomy to control bleeding in one case.

Hospital financial records were available for 96 patients, of whom 22 were discharged from the hospital early, 11 were observed for an extended outpatient period, and the remainder were retained for inpatient hospitalization. Average net hospital incomes on technical charges for patients in the inpatient hospitalization, extended outpatient observation, and short-stay (early discharge) groups were $1778, $1175, and $1219, respectively, in 1997, but declined to $889, $1339, and $671, respectively, in 1998. The ratios of indirect costs to direct technical costs were 132.5%, 128.7%, and 103.7%, respectively.

Conclusions. Early discharge of patients following SBB of supratentorial lesions is safe in the absence of excessive intraoperative bleeding, new postoperative deficit, and clot on a postoperative CT scan. Extended outpatient observation (8–23 hours) is not clinically necessary and may be economically prohibitive in the setting of a teaching hospital.

Key Words • biopsy • stereotactic biopsy • frameless stereotaxis • surgical navigation • outcome • cost analysis

Image-guided SBB has become a mainstay in the management of brain tumors and other brain lesions.1,2 Although in many reports the low incidence of complications as well as the efficacy of this diagnostic procedure has been documented,1,4,5,6,11,12,13,16,18,22,25–24 there is little information on the timing of perioperative complications of SBB14,22 and none on the economic impact of length of stay after SBB. These data are important because they may be used to make rational clinical decisions regarding the appropriate length of postoperative monitoring and to provide clinical guidelines for discharge from the hospital while defining the economic pressures that may bear on the length of stay after SBB.

In this study we set out to determine the timing and nature of perioperative complications in a series of patients who had undergone SBB. These data were then used to generate guidelines for early discharge (that is, <8 hours post-SBB) of patients and were then applied to a later series of patients. In this paper we review the subsequent clinical and economic outcomes of this management strategy.

Clinical Material and Methods

Group A Patients

Group A consisted of all patients who had undergone...
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Percutaneous SBBs performed at The Cleveland Clinic Foundation during 1994 and 1995. Case data were reviewed using information obtained from a database of these procedures and the patients’ medical charts. Clinical and radiological complications and their timing, and the incidence of intraoperative hemorrhage through the biopsy cannula were recorded. Patients who had undergone open biopsy or additional procedures in the same surgical setting (for example, cyst aspiration, catheter placement, and brachytherapy) and those in whom no postoperative CT scan had been obtained were excluded from review for the purpose of uniformity.

Routine postoperative management included a short stay in a recovery unit (<12 hours post-SBB) during which CT scanning was performed 1 to 3 hours after surgery for the purpose of triage. Patients were then transferred to a regular nursing floor for observation unless a new neurological deficit appeared, excessive intraoperative bleeding had occurred, the CT scan revealed hemorrhage (that is, >1 cm confluent increased density), or the focus of the biopsy was the posterior fossa. Patients were routinely discharged on the 1st postoperative day unless complications were identified or a further workup or treatment was indicated.

**Group B Patients**

In Group B, information on the nature and timing of perioperative complications was collected in all patients who had undergone percutaneous SBB from January 1996 through July 1998. The timing of postoperative CT scanning and the exclusion criteria were the same as those for Group A; however, discharge management was based on guidelines (see Results) allowing for early discharge (<8 hours) of some patients following SBB.

**Biopsy Methods**

The biopsy procedures were performed using either CT or magnetic resonance image guidance with the aid of either a Cosman–Roberts–Wells frame stereotaxy system (Radionics, Burlington, MA) or a frameless surgical navigation system (ViewPoint; Picker International, Highland Heights, OH and DePuy-Acromed, Raynham, MA).2,3 Tissue was obtained through a twist drill hole by using a side-cutting biopsy instrument (Compass International, Inc., Rochester, MN). Most biopsies were performed after general anesthesia had been induced in the patient, in accordance with the surgeon’s preference. Details of the biopsy procedure and techniques have been presented elsewhere.2,3,4 The majority of procedures were performed under the supervision of the senior author (G.H.B.).

**Economic Analysis**

Several hospital financial databases were queried to extract information on length of stay, hospital charges, net revenue, direct costs, and indirect costs for patients who had undergone SBB. This information was available for calendar years 1997 and 1998 only and, thus, does not directly match the patient populations of Groups A or B. Lengths of stay following SBB were categorized as short stay (or early discharge, <8 hours), extended outpatient observation (≥8 and <24 hours), and inpatient hospitalization (≥24 hours). Indirect costs include shared general facility costs such as utilities, maintenance, depreciation on buildings and equipment, security, and so forth. The average net income from technical charges (that is, excluding professional revenues and costs) was calculated for each stay category as the difference between average net revenue and average cost (direct plus indirect costs).

**Statistical Analysis**

The Fisher exact test was used to assess associations between intraoperative bleeding and the presence of a postoperative clot as demonstrated on postoperative CT scans, as well as between the presence of a clot on postoperative CT scans and postoperative neurological deterioration. The assumption of these analyses was that repeated biopsies performed in five patients were events independent of the initial biopsy procedure. A significance level of probability equal to 0.05 was used.

**Results**

**Group A: Retrospective Review**

One hundred thirty image-guided SBBs were performed in 1994 and 1995. The average patient age was 55 years. The results of biopsies signified the diagnosis of neoplasm (84%) most often, whereas the remainder were abscess, demyelination, vasculitis, and other processes (Table 1). One hundred twenty-six biopsied lesions were supratentorial and four were infratentorial. (Because of the small number of infratentorial lesions, they have been excluded from the risk and financial analyses.) All patients underwent CT scanning of the brain within a few hours postoperatively. Seventy-three patients were admitted on the day of the procedure; the others had been previously admitted for symptomatic disease.

**Complications.** All clinical and radiographic complications directly related to the procedure were identified within 6 hours of surgery. No delayed complications that could be attributed to the biopsy procedure were identified.

**Morbidity.** One patient suffered permanent homonymous hemianopsia (Table 2). This was the result of an occipital hematoma, which was evacuated on an emergency basis within a few hours after the biopsy procedure. Four patients awoke with neurological deficits that proved to be transient. In two of these patients, hemorrhagic complica-
Complications could be observed on the postoperative CT scans. In the remaining two patients, no new evidence of hemorrhage was demonstrated on postoperative scans. All these patients were admitted to an ICU and treated with steroid medications. None required any surgical intervention and all experienced resolution of their symptoms within a few days postoperatively. One patient experienced an asymptomatic intraventricular hemorrhage. This patient was also admitted to an ICU for observation overnight and subsequently discharged without further complications.

**Intraoperative Hemorrhage.** In 12 patients there was no-table (10–50 ml) intraoperative bleeding through the biopsy cannula. This bleeding was satisfactorily stopped in all patients. Significant hematoma was observed on postoperative CT scans in only two of the 12 patients, resulting in a postoperative hemorrhage rate of 16.7%. One patient required emergency craniotomy for clot evacuation and the other experienced a mild transient deficit and was treated with steroid medications. In the remaining 10 patients, no radiological or clinical consequences occurred as a result of the intraoperative bleeding.

**Mortality.** Four patients (3.1%) died during postoperative hospitalization. Only one (0.8%) death was due to the biopsy procedure, the patient having suffered a large temporal hematoma immediately post-SBB. Although the patient underwent emergency evacuation of the hematoma, devastating neurological damage had been sustained and the patient died on the 4th postoperative day. The remaining three deaths were caused by natural progression of disease and occurred 4 to 13 days postsurgery.

**Results of the Statistical Analysis.** Table 3 shows the association between clinical complications and CT scan–documented hemorrhage in Group A. Among 124 patients with no clinical complications, no hemorrhage was demonstrated on the postoperative CT scans in 123 (99.2%; 95% CI 95.6–100). Conversely, in the six patients who experienced clinical deterioration postoperatively, hemorrhage was revealed on CT scans in four (66.7%; 95% CI 22.3–95.7). This association between CT scan–documented hemorrhage and neurological deterioration is statistically significant (p < 0.001).

There was a marginal association between intraoperative bleeding and CT scan–documented hemorrhage. In two (16.7%; 95% CI 2.1–48.4) of the 12 patients who had suffered intraoperative bleeding, hemorrhage was documented on the postoperative CT scan; this can be compared with only three (2.5%; 95% CI 0.5–7.3) of the 118 patients who did not experience intraoperative bleeding. This association did not reach statistical significance (p = 0.067, Fisher exact test).

**Group B: Planned Early Discharge**

Group B included 139 biopsies. The average patient age was 53 years. The diagnoses are presented in Table 1. Only eight patients harbored infratentorial lesions, and because of their small number, data in these patients are excluded from the risk and financial analyses. Fifty-three patients had been previously admitted to the hospital for symptomatic disease; 86 patients were admitted to the hospital on the day of the procedure.

**Complications.** All but two complications occurred within 6 hours postsurgery (Table 2). In one patient an abscess developed and became symptomatic 3 weeks after the procedure. In another case, a small cerebrospinal fluid leak occurred 2 weeks following SBB in a patient who underwent intratumoral chemotherapy.

**Morbidity.** One patient suffered permanent severe brainstem injury after having undergone an SBB of a lesion in the brachium pontis (Table 2). A pontine clot was revealed on the postoperative CT scan in this patient. Another patient suffered significant neurological impairment due to the development of a cerebral abscess at the location of the biopsy site. He presented 3 weeks following SBB and was treated with antibiotic agents. This patient represented the only case of delayed neurological complication in this group.

Other clinical complications included transient deficits, which were experienced by two patients; one was found to have a small clot, which was demonstrated on the CT scan and treated nonoperatively, and no significant findings were observed on the postoperative CT scan in the other patient. One patient had to undergo a minimal craniotomy to control refractory bleeding through the biopsy cannula. Last, in three patients there were asymptomatic clots that caused no delayed deterioration during follow-up observation in the hospital.

**Intraoperative Hemorrhage.** Eleven patients in Group B suffered intraoperative hemorrhage. One required open surgery from the biopsy procedure and the other required emergency craniotomy for clot evacuation and treatment with steroid medications. In the remaining 10 patients, no radiological or clinical consequences occurred.
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**Economic Analysis**

Hospital financial records were available for 96 patients, of whom 22 were allowed early discharge, 11 received extended outpatient observation, and the remainder were detained for inpatient hospitalization. Revenue declined 14% in the short-stay group and 45% in the extended outpatient observation group, whereas direct costs increased 16% and 28%, respectively. Average net hospital incomes on technical charges in the inpatient hospitalization, extended outpatient observation, and short-stay groups were $1778, $1175, and $1219 in 1997, and declined to −$889, −$1339, and $671, respectively, in 1998 (Table 4).

The ratios of indirect costs to direct costs were 132.5%, 128.7%, and 103.7%, respectively. Direct costs associated with the early discharge (short-stay) group were attributed to nursing 59%, anesthesia 22%, administration 7%, radiology 6%, pathology 5%, and pharmacy 2%.

Revenue was 6% higher in the extended outpatient observation group compared with the short-stay group, whereas direct costs were 35% higher. Factors that contributed to the increase in costs above that of the short-stay group included the following: pathology (that is, laboratory) 41%, nursing 35%, anesthesia 12%, radiology 4%, pharmacy 3%, and miscellaneous for the remainder.

**Discussion**

Contemporary frame and frameless stereotactic systems provide accurate access to intracranial targets when combined with CT or magnetic resonance imaging for guidance.1–3,11,15 Although there are many reports on the overall results and complications of image-guided SBB and related procedures,4,8–10,16,18,22–24 there is little information on the timing of these complications. Bernstein and associates4 reported that most complications in their series (that is, 16 of 19 cases) occurred within a few hours after the procedure. Three of their patients experienced delayed complications (8–48 hours post-SBB), despite an unremarkable immediate postoperative status. In a more recent series undertaken at the same institution, Kulkarni, et al.,14 reported on three patients with delayed clinical deterioration, two of whose conditions deteriorated on the 1st postoperative day and one of whose condition deteriorated on the 2nd postoperative day. In all three patients, clinically asymptomatic hemorrhages were demonstrated on CT scans obtained immediately postoperatively.

Our data indicate that nearly all clinically or radiographically significant early complications following image-guided SBB are detectable within 6 hours after the procedure, and a longer observation time did not result in the detection of delayed deterioration. This finding has important implications for determining the length of postoperative monitoring following an uncomplicated biopsy, because certain patients may be discharged safely on the day of the procedure. The ability to identify appropriate

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**TABLE 4**

<table>
<thead>
<tr>
<th>Patient Category</th>
<th>Length of Stay</th>
<th>No. of Cases</th>
<th>Net Revenue</th>
<th>Direct Costs</th>
<th>Indirect Costs</th>
<th>Net Income</th>
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<tr>
<td>inpatient hospitalization</td>
<td>6.60 days</td>
<td>30</td>
<td>$2.64A</td>
<td>$D</td>
<td>$1.13D</td>
<td>$1778</td>
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<td>extended outpatient observation</td>
<td>8–23 hrs</td>
<td>7</td>
<td>$A</td>
<td>$C</td>
<td>$1.42C</td>
<td>$1175</td>
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<td>short-stay</td>
<td>&lt;8 hrs</td>
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<td>$0.85A</td>
<td>$B</td>
<td>$1.51B</td>
<td>$1219</td>
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<td>1998</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>inpatient hospitalization</td>
<td>7.79 days</td>
<td>33</td>
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<td>$1.36D</td>
<td>$1.09D</td>
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<td>$1.42C</td>
<td>−$1339</td>
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<tr>
<td>short-stay</td>
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<td>$0.73A</td>
<td>$1.16B</td>
<td>$1.34B</td>
<td>$671</td>
</tr>
</tbody>
</table>

* The variables used in this table are applicable for both 1997 and 1998. The assertion that short-stay outpatient net revenue declined 14% can be determined by taking the net revenue from 1997 and subtracting the net revenue from 1998; the difference is divided by the net revenue from 1997 and multiplied by 100%: (−$0.85A − $0.73A)/$0.85A × 100% = 14%.

Abbreviations: A = extended observation outpatient net revenue; B = short-stay outpatient direct costs; C = extended observation outpatient direct costs; D = inpatient direct costs.
candidates for early discharge (that is, candidates for outpatient surgery) could lead to significant reductions in health care costs by avoiding unnecessary hospital admissions.

In this study the most frequent complication was the occurrence of transient deficits. This is consistent with the results of other series. These deficits may be due to hemorrhage at the biopsy site, which is readily identified on postoperative CT scans; local tissue edema; or direct tissue trauma. These patients should be monitored closely and, in our experience, most respond well to steroid medications. They should not be considered for early discharge. Follow-up CT scanning or other imaging should be performed to follow hemorrhagic complications demonstrated on the immediate postoperative image. Additional neuroimaging is also indicated to investigate the cause of these deficits if they should persist unexplained or if there is suspicion of another coincidental pathological condition.

Only two (16.7%) of 12 patients with intraoperative bleeding had significant postoperative hematoma, and only one of these patients required craniotomy for evacuation of the hematoma. In their series of 318 biopsies, Sedan and colleagues reported 14 cases (4.6%) of bleeding through the biopsy cannula. One of these 14 patients experienced a transient deficit; the others did not suffer any clinical consequence. No postoperative imaging data were reported. Nizuma and coworkers reported an incidence of 9% with no clinical symptoms. In nearly half of their patients, there was evidence of blood on postoperative CT scans, but none of their patients displayed immediate or delayed deterioration. Voges, et al., also reported a poor correlation between intraoperative bleeding and clinical outcome. Our results in Group A patients demonstrate a poor correlation between intraoperative bleeding and postoperative radiographic evidence of hemorrhage (16.7%); in other words, only a minority of these patients experienced a postoperative hemorrhage. Our analysis revealed no statistically significant difference in the rates of postoperative hemorrhage between patients who experienced intraoperative bleeding and those who did not. Unfortunately, our numbers are too small to allow us reliably to conclude that intraoperative bleeding does not increase the risk of postoperative complications. Additionally, the two patients with hemorrhagic complications in this subset of patients represent 40% (two of five) of the total number of hemorrhagic complications in the overall group. Thus, we must consider intraoperative hemorrhage to be a risk factor for the development of postoperative hemorrhage, and we must monitor these patients overnight regardless of their postoperative clinical status. Our management of intraoperative bleeding has been reported previously. Our method consists of elevating the head and maintaining patency of the biopsy cannula (by replacing the stylet periodically) to channel the blood extracranially. Thrombin application is reserved for persistent or arterial bleeding.

The presence of postoperative deficit was a fair predictor for intracerebral hemorrhage (66.7%; 95% CI 22–95.7%). In two of our patients, these clots required emergent evacuation. The remaining patients did not exhibit clinical or radiographic progression of clots after hospital observation or on serial CT scans. Nonetheless, the potential for clot extension warrants observation, blood pressure management, and correction of any coagulation disorders necessitating hospital, and preferably ICU, admission.

In the absence of postoperative deficit within the first 6 hours following SBB was highly associated with absence of significant clot on the postoperative CT scan (99.2%; 95% CI 95.6–100). This does not, however, obviate the need for routine postoperative CT scanning in asymptomatic patients, unless the patient is scheduled to be monitored in the hospital at least 1 day following the biopsy. We believe that it is necessary to obtain a CT scan in asymptomatic patients if they are to be considered for early discharge. The report by Kulkarni, et al., indicates that a small percentage of their patients suffered from clinically asymptomatic hemorrhages that caused delayed neurological deterioration. The radiological detection of these clinically asymptomatic hemorrhages is, therefore, necessary if early discharge of patients is to be considered.

Interestingly, in this group, postoperative CT scanning detected only one clinically asymptomatic hemorrhage and, in this particular case, the patient did not experience a delayed complication during the extended hospital stay. This is probably explained by the fact that the hemorrhage was intraventricular and not intraparenchymal and, therefore, it could cause no focal deficit. Thus, at present we believe that noncontrast CT scanning is a simple, readily available, and inexpensive means of screening asymptomatic patients for occult clots that have the potential to develop later into frank hemorrhages. Unremarkable findings on CT scans obtained in asymptomatic patients are important to the process of selecting patients for early discharge.

Although no patient meeting our guidelines for safe discharge unexpectedly deteriorated between 6 and 23 hours after surgery, we do not intend to suggest that such a deterioration is impossible. Rather, our results indicate that when proper biopsy methods, patient selection, and triage procedures are followed, such events are exceedingly rare and probably do not justify overnight observation.

Posterior Fossa Biopsy

Only four patients in Group A underwent biopsy of lesions located in the posterior fossa. Because of the potential for rapid deterioration from small increases in the volume of posterior fossa contents and because the results of this study are inconclusive, we continue to monitor most of these patients overnight and have not included them in the risk or financial assessment. It should not, then, be concluded that the observations or analyses presented in this paper pertain to biopsies in the posterior fossa. A patient population larger than the one we present in this report will be required to address safety issues in that subset of patients.

Economic Analysis

The number of patients in the outpatient groups were small (total 33) and, thus, these results should be interpreted with caution; however, several trends emerged.

Net hospital income on technical charges was higher for patients discharged early than for those kept for an overnight stay, despite slightly higher (6%) net revenue in the latter group (average 1997 and 1998). In 1998, the hospital...
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tal actually lost income on this procedure in patients who were in the extended outpatient observation group due to declining revenues. The difference in direct costs was principally attributed to increased costs of laboratory tests and nursing care during the extra hours of observation. In both outpatient groups, however, indirect costs substantially exceeded direct costs, reflecting the high operational costs of a tertiary care teaching hospital. It is unlikely that any meaningful changes in physician practice would reduce direct costs to the point at which overnight observation of these patients would be profitable. Patients discharged early (< 8 hours) proved to be the only patient group in 1998 in which net revenue for the hospital was positive.

Brain biopsy performed in inpatients also resulted in negative revenue in 1998, in part due to higher direct costs (for example, increased length of stay) but primarily due to reduced revenue. Interpretation of data for this group is difficult because SBB is often only one component of investigations performed during a hospitalization for a diverse array of neurological diseases. Also, analysis of data may potentially be confounded by its being collected during two different time periods. Nonetheless, it does reflect the expected trends of increasing costs and declining reimbursement over time. This information does indicate, however, that hospitalizations involving brain biopsy may result in a net financial loss for the hospital.

Influence of Practice Patterns

Practice patterns peculiar to our institution that could potentially influence cost are the use of general anesthesia during SBB and the routine use of post-SBB CT scans. The senior author’s preference for performing SBB after the induction of general anesthesia evolved from a time when monitored anesthesia care was used to control more adequately or to prevent intraoperative untoward events such as hemorrhage, seizures, and self-extraction from the fixation device. No complications due to general anesthesia were observed in the current series and, in general, this practice does not lead to increased costs. At our institution, an anesthesiologist must supervise all cases, even if surgery is performed with the patient in a state of local anesthesia monitored by a certified registered nurse-anesthetist. Thus, there is no meaningful difference in personnel charges between these methods. Furthermore, the cost of medication and equipment for monitored anesthesia care may, in some cases, exceed that for surgery performed with the patient in a state of general anesthesia.

Routine postoperative CT scanning adds to the cost of the procedure, but must be weighed against savings of an additional 14 hours of hospital observation that may be avoided. This translates to an increase of $185 for CT scanning and a savings of $302 in nursing costs.

Management Guidelines

On the basis of the aforementioned analysis we have established guidelines for the postoperative management of ambulatory patients with manageable neurological deficits who are about to undergo supratentorial image-guided SBB. 1) Patients undergoing image-guided SBB should be closely monitored for at least 6 hours postoperatively to detect clinical deterioration promptly. 2) Routine postoperative CT scanning should be performed within this same time period to detect clinically asymptomatic hemorrhage (> 1 cm in diameter). 3) Treatment should be individualized for patients who demonstrate clinical or radiological complications. 4) In the absence of intraoperative hemorrhage, new postoperative deficit, or complications demonstrated on radiography, patients may be discharged from the hospital to adequate home monitoring at the end of this observation period.

These guidelines have been applied since 1996. The population characteristics of Group B are similar to those of Group A, and we assume that there are no inherent differences between the two groups that might preclude making outcome comparisons. The complication profiles of the two groups are comparable. In Group A patients, we found no delayed complications. In Group B patients, the only delayed complications were those that became symptomatic weeks after the biopsy procedure. Consequently, these complications could not have been detected, even if these patients were kept in the hospital for a routine observation period of 1 or 2 days.

We found that application of these guidelines has enabled us to discharge some patients on the same day as the procedure. Of 71 patients in Group B who were potential candidates for same-day discharge, 58 fulfilled the aforementioned criteria and were safely discharged. This 81% early discharge rate translates to a substantial reduction in costs at no apparent increase in patient risk. It also removes these patients from the risk of iatrogenic complications that could occur during overnight hospitalization.

Conclusions

Clinically significant complications after image-guided SBB are detectable during the first 6 hours after surgery. In a subgroup of patients, extended outpatient observation is not clinically necessary in the absence of excessive intraoperative bleeding, new postoperative deficit, and clot on delayed postoperative CT scans, and may be economically prohibitive in the setting of a teaching hospital.

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