Cost of radiofrequency ablation in the treatment of hepatic malignancies


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SUMMARY

Objectives — Our primary objective was to assess the cost of radiofrequency ablation (RFA) of hepatic malignancies and to compare it to hospital reimbursement paid in the French Prospective Payment System (PPS).

Patients and methods — A series of 305 patients were enrolled into a prospective study. All resources used during the RFA-related hospital stay were recorded. Costs were assessed from the perspective of the health care providers and computed for four groups of patients: percutaneous RFA in an outpatient setting (group Ia, N=44), percutaneous RFA in an inpatient setting (group Ib, N=94), laparoscopic RFA (group II, N=44) and intraoperative RFA combined with resection (group III, N=120).

Results — Mean hospital costs were estimated at €1581 (group Ia), €3824 (group Ib), €8194 (group II) and €12967 (group III). Costs per stay without intensive care in these groups were respectively €1581, €3635, €6622 and €10905 and reimbursement (intensive care excluded) was €560, €3367, €9084 and €11780.

Conclusion — In the French PPS, the cost of RFA is covered by lump sums paid to hospitals exclusively for intraoperative and laparoscopic RFA. For percutaneous RFA, which is the most frequent approach, reimbursement is highly insufficient.

RÉSUMÉ

Coût de la radiofréquence dans le traitement des tumeurs malignes hépatiques


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Objectifs — Le but de cette étude était d’évaluer le coût de la radiofréquence (RF) hépatique et de le comparer à la rémunération attribuée aux établissements dans le cadre de la tarification à l’activité (T2A).

Malades et méthodes — Trois cent cinq malades ont participé à une étude prospective. Les ressources utilisées au cours de l’hospitalisation ont été relevées. Les coûts ont été évalués du point de vue des établissements de soins pour quatre groupes de malades : RF percutanée en hospitalisation de jour (groupe Ia, N=44), RF percutanée en hospitalisation conventionnelle (groupe Ib, N=94), RF par voie cœlioscopique (groupe II, N=44) et RF peropératoire associée à une résécion chirurgicale (groupe III, N=120).

Résultats — Le coût moyen par séjour était de 1 581 € (groupe Ia), 3 824 € (groupe Ib), 8 194 € (groupe II) et 12 967 € (groupe III). Hors réanimation, les coûts par séjour étaient respectivement de 1 581 €, 3 635 €, 6 622 € et 10 905 €. Les tarifs T2A (hors réanimation) étaient de 560 €, 3 367 €, 9 084 € et 11 780 €.

Conclusion — Le coût par séjour est couvert par le tarif T2A pour la radiofréquence intraopératoire et cœlioscopique, mais il est insuffisant pour la radiofréquence percutanée qui est l’approche la plus fréquente.
tumours or during laparoscopy. The safety and local efficacy of RFA in hepatic malignancies are well documented [2-11], but the economic aspects of RFA are scarce in the literature. Only two studies focusing on the economic aspects of RFA have been identified [12-13]. Unfortunately, both studies used a decision-analysis model in which the cost of the RFA procedure was based on assumptions rather than on observed data. Our objective was to assess the cost of the RFA procedure (percutaneous, laparoscopic and intraoperative combined with surgical resection) and related inpatient costs in primary and secondary hepatic malignancies in a French setting. We also aimed at comparing the cost of RFA to hospital reimbursement paid in the French Prospective Payment System (PPS).

Methods

Between January 2002 and December 2003, a series of consecutive patients with hepatic malignancies in six medical centres (five comprehensive cancer centres and one teaching hospital) were enrolled into a prospective study of RFA. RFA was used as first-line treatment for small primary HCC or for newly discovered tumours after initial hepatectomy or RFA. RFA was often preferred to surgery because of poor liver function. RFA was used percutaneously for LM that respond to systemic chemotherapy and which had a diameter measuring less than 4 cm. RFA was used in addition to surgical resection of LM aimed at larger tumours. RFA was performed using four commercially available systems: Radiomics™, Boston Scientific™, RITA™ and Berchtold™. Three RFA approaches were distinguished: percutaneous, laparoscopic and intraoperative combined with a surgical resection. The RFA approach was chosen by the surgeon or the radiologist. Whatever the RFA approach, the needle electrode was positioned centrally in the lesion under ultrasound guidance. When the probe was correctly positioned, tumour ablation was performed under ultrasound or computed tomography scan guidance and according to the manufacturer’s protocol. Radiofrequency areas included all tumour tissue including at least a one centimetre safety margin.

We assessed the cost of the RFA procedure and the cost of the RFA-related hospital stay from the perspective of the health care providers. The cost of the procedure was computed using the data concerning the first RFA procedure recorded for each patient enrolled in the study. Patient-specific data on the use of resources during the hospital stay for RFA approaches were collected. Resources included the number of bed-days per unit type, the duration of the RFA procedure, the duration of any procedure post RFA (treatment of complications), specific supplies including the type of radiofrequency needle electrode, imaging and biological work-up, medications and blood products. Logistics costs and overheads were included in order to assess the full cost of the hospital stay. A separate cost analysis was performed for the three different RFA approaches. Percutaneous RFA was performed in an interventional radiology unit whereas laparoscopic and intraoperative RFA required an operating room and a surgical team. Among patients treated with percutaneous RFA, two groups were distinguished according to treatment in an inpatient and in an outpatient setting. Costs are presented in four groups: percutaneous RFA in an outpatient setting (group Ia), percutaneous RFA in an inpatient setting (group Ib), laparoscopic RFA (group II) and intraoperative RFA combined with resection (group III). We collected site-specific cost information to value resources. Each hospital provided accounting data information and specific unit costs (e.g. hourly wages of medical staff, medication costs) for micro-costing. The ranges of cost units observed in the centres are summarized in table I. Costing methodology is detailed in the appendix I. Regarding reimbursement, we used the distribution of days between diagnosis-related groups (DRGs) in our study to calculate a mean reimbursement per each RFA type. Reimbursement per DRG does not include intensive care which is reimbursed separately in the French PPS. Therefore, to compare costs and reimbursements, we recalculated costs without intensive care.

Major abdominal and extra-abdominal complications during the hospital stay were prospectively recorded. The following intra-abdominal complications were considered to be related to RFA: subcapsular haematoma, intra-abdominal haemorrhages, hepatic abscesses, biliary stenosis/fistulas, segmental portal thromboses, severe inflammatory syndromes and liver failure. Furthermore, complications were classified as major if the duration of the hospital stay was prolonged by 2 days at least or if a new intervention was required [14]. As it was unclear whether or not extra-hepatic complications were directly related to RFA, we have reported them separately.

Results

Patients

Three hundred and five patients were enrolled into the study. The median number of patients included per centre was 43 (range: 18-111). Our study population included 129 women and 176 men who were 62±12 (mean ± standard deviation) years old bearing 95 hepatocellular carcinomas (84 patients) and 453 liver metastases (221 patients). One hundred and thirty-nine patients underwent percutaneous RFA (group I), 44 laparoscopic RFA (group II) and 121, resection combined with intraoperative RFA (group III). The distribution of the patients according to the type of hepatic tumour and the type of RFA approach is shown in figure 1.

Hepatocellular carcinoma

A mean of 1.1 tumours (range: 1-3) were treated with RFA. The largest tumour dimensions ranged from 3 to 70 mm with a mean value of 29.7 mm. Ninety percent of patients had cirrhosis whose origin was as follows: alcohol (47%), hepatitis C (43%) and hepatitis B (7%) and unknown/healthy liver (3%). Twenty-four percent of patients had previously undergone a hepatectomy (10%), or had been treated with an ethanol injection (7%), chemo-embolisation (7%) and/or RFA (6%).

Liver metastases

A mean of 2.1 tumours (range: 1-10) were treated with RFA. The largest tumour dimensions ranged from 5 to 55 mm with a
mean value of 18 mm. The origin of LM was mainly colorectal (69%) and breast (11%). LM were synchronous in 58% of the patients. All patients with LM had received treatment for their hepatic tumours before RFA: 83% had received chemotherapy, 26% had undergone surgical resection and/or had had a prior RFA (5%). The subgroup of patients with LM treated with percutaneous RFA (N=61) had responded to chemotherapy. Extra-hepatic disease was present in 38 patients (17%) with LM and was resected at the same time as intraoperative RFA. In patients treated with intraoperative RFA combined with resection, the mean number of hepatic tumours was 5 (range: 1-37): on average, 2.3 tumours were treated with RFA and the remaining tumours were surgically resected.

Radiofrequency procedure and types of surgical resection

Thirty-six percent of RFA procedures were performed using the Radionics™ system with a single needle, 11%, the Radionics™ system with a cluster needle, 19%, the Boston Scientific™ system, 19%, the RITA™ system and 15%, the Bertchtold™ system.

The median duration of the procedure was 82 minutes (range: 23-240 minutes) in group I, 245 minutes (range: 140-511 minutes) in group II and 360 minutes (range: 135-800 minutes) in group III. In group III, there were 89 hepatectomies (including 45 extended hepatectomies). The main other types of resection were rectal and colon resections, cholecystectomies or peritoneal resections.

The mean number of RFA procedures per patient was 1.2 (range 1-5). It ranged from 1 to 1.7 from one centre to another. The percentage of patients who had a second RFA procedure ranged from 2% to 43% between centres. Patients with HCC were more likely to have a second RFA procedure than patients with LM: 31% versus 17% (P<0.0001).

RFA complications during the hospital stay

Three post-operative deaths were observed in group III (following 2 hepatectomies and 1 peritoneal resection). The causes of deaths were: pulmonary embolism, myocardial infarction and biliary necrosis. Seventeen patients (6%) had RFA-related intra-abdominal complications (table II). The rate of RFA-related intra-abdominal complications was 3% in group I, 7% in group II and 9% in group III. Twenty-seven patients (9%) had extra-abdominal complications (mostly pulmonary, urinary infections and cardiac complications).

Table II. – Number of patients with complications during hospital stay.

<table>
<thead>
<tr>
<th></th>
<th>Group I (N=138)</th>
<th>Group II (N=44)</th>
<th>Group III (N=110)</th>
<th>All (N=292a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one abdominal complication</td>
<td>4 (3%)</td>
<td>3 (7%)</td>
<td>10 (9%)</td>
<td>17 (6%)</td>
</tr>
<tr>
<td>At least one extra-abdominal complication</td>
<td>4 (3%)</td>
<td>7 (16%)</td>
<td>16 (15%)</td>
<td>27 (9%)</td>
</tr>
<tr>
<td>Deathb</td>
<td>0</td>
<td>0</td>
<td>3 (2%)</td>
<td>3 (1%)</td>
</tr>
<tr>
<td>At least 1 complication (all causes)</td>
<td>7 (5%)</td>
<td>9 (20%)</td>
<td>22 (20%)</td>
<td>38 (13%)</td>
</tr>
</tbody>
</table>

Group I: percutaneous RFA, Group II: laparoscopic RFA, Group III: intraoperative RFA and surgical resection.

a: Information was missing for 13 patients. Rates of complications (deaths excluded) were calculated based on 292 patients; b: The rate of deaths was calculated based on 122 patients. Causes of deaths were: pulmonary embolism, myocardial necrosis and biliary necrosis.
Cost analysis

Data on the RFA procedure or the hospital stay were missing for 3 patients (1 patient in group I and 2 patients in group III). Therefore, the economic results reported concern 302 patients.

One-third of the stays in group I lasted less than 24 hours (group Ia). In group Ib, the median duration of the hospital stay was 3 days (range: 1-28 days). The mean duration of the hospital stay was 9 days (range: 5-33 days) in group II and 13 days (range: 7-50 days) in group III. Forty-four patients (41 patients in group III and 3 patients in group I) were hospitalised in an intensive care unit (ICU) for at least one day.

The mean cost per hospital stay was €1581 (range €1356-€2468) in group Ia, €3824 (range €2280-€29721) in group Ib, €8194 (range €3022-€22546) in group II and €12967 (range €5339-€65269) in group III. Table III details inpatient costs per RFA approach. The mean cost of the RFA needle electrode was €756 (range: €212-€1433). We isolated the cost of intensive care because it is reimbursed separately in the French PPS. Costs per stay without intensive care were €1581 in group Ia, €3635 in group Ib, €6622 in group II and €10905 in group III.

The economic impact of RFA complications was a longer duration of the hospital stay (plus 2 days in group I and plus 6 days in groups II and III) and an added cost of €1660. The distribution of inpatient costs per RFA approach is shown in figure 2. It should be underlined that inpatient costs were more due to surgery than to RFA in group III.

Table III. – Mean cost of hospital stay with RFA in 2005 (€).

Coût moyen d’un séjour avec radiofréquence en 2005 (€).

<table>
<thead>
<tr>
<th>Cost components</th>
<th>Group Ia, DOS≤24 hours (N=44)</th>
<th>Group Ib, DOS&gt;24 hours (N=94)</th>
<th>Group II (N=44)</th>
<th>Group III (N=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating time</td>
<td>609</td>
<td>916</td>
<td>2054</td>
<td>4226</td>
</tr>
<tr>
<td>RFA needle electrode</td>
<td>424</td>
<td>1074</td>
<td>706</td>
<td>647</td>
</tr>
<tr>
<td>Inpatient days:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General and surgical care units</td>
<td>499</td>
<td>1497</td>
<td>3475</td>
<td>5368</td>
</tr>
<tr>
<td>Intensive care unit</td>
<td>0</td>
<td>189</td>
<td>1572</td>
<td>2062</td>
</tr>
<tr>
<td>Imaging work-up</td>
<td>40</td>
<td>46</td>
<td>97</td>
<td>173</td>
</tr>
<tr>
<td>Biological work-up</td>
<td>5</td>
<td>62</td>
<td>183</td>
<td>285</td>
</tr>
<tr>
<td>Medications</td>
<td>5</td>
<td>18</td>
<td>78</td>
<td>118</td>
</tr>
<tr>
<td>Blood products</td>
<td>0</td>
<td>22</td>
<td>30</td>
<td>88</td>
</tr>
<tr>
<td>Cost per stay</td>
<td>1581</td>
<td>3824</td>
<td>8194</td>
<td>12967</td>
</tr>
<tr>
<td>Cost per stay without intensive care</td>
<td>1581</td>
<td>3635</td>
<td>6622</td>
<td>10905</td>
</tr>
</tbody>
</table>

Group Ia: percutaneous RFA in an outpatient setting, Group Ib: percutaneous RFA in an inpatient setting, Group II: laparoscopic RFA, Group III: intraoperative RFA and surgical resection. 
DOS: duration of stay.

Fig. 2 – Distribution of costs per stay.

Distribution des coûts par séjour.
Prospective payment for RFA

RFA stays were mainly assigned to five DRGs depending on the RFA approach. Reimbursements per stay (intensive care excluded) for these DRGs in 2005 ranged from €560 to €14477 (table IV). Group Ia and group II stays were each classified into a specific DRG. The mean reimbursement for these stays was therefore the lump sum corresponding to the DRG under consideration. In contrast, group Ib and group III stays were each classified into two specific DRGs. The mean reimbursement was computed based on the lump sums corresponding to these DRGs weighted by the observed distribution (one-third/two thirds for group Ib and fifty/fifty for group III). The mean reimbursement was €560 in group Ia, €3367 in group Ib, €9084 in group II and €11780 in group III (table V). Reimbursement appears to cover inpatient costs for laparoscopic and intraoperative RFA but not for percutaneous RFA which is the most frequent approach.

Discussion

Our objective was to assess hospital costs of RFA in a prospective, multi-centre study. The cost of the RFA needle electrode accounted for 28%, 9% and 5% of hospital costs in groups I, II and III, respectively. Percutaneous RFA is minimally invasive and can be performed on an outpatient basis. For intraoperative RFA combined with a surgical resection, the added cost of RFA is likely to be negligible compared to that of surgery.

Knowing the cost of new treatments is of strategic interest because the French hospital financing system is being totally reframed. Hospitals are now partially reimbursed for inpatient services under a Prospective Payment System (PPS) implemented in 2004, the so-called “Tarification à l’activité ou T2A”. Before the PPS was implemented, hospitals were allocated a global budget regardless of the volume and the type of medical activity. Under the current PPS, the budget allocated to a hospital is directly related to its hospital activity. The activity is measured using a DRG classification. A stay is assigned to a single DRG and each DRG is allocated a unique predetermined lump sum. The lump sum per DRG is determined by the French Ministry of Health and is adjusted annually. A hospital’s resources are then allocated according to its casemix activity. In such a context, it is important for a hospital to know if a particular activity is profitable or not. In the case of RFA, we show that the current lump sum for the DRGs under consideration covers inpatient costs for RFA procedures performed on an inpatient basis but does not cover procedures performed on an outpatient basis. Thus there is a counterproductive incentive for hospitals to prolong the hospital stay beyond 24 hours in the case of percutaneous RFA.

In the USA, where a PPS also exists, reimbursement information is available for RFA. Two studies attempted to evaluate the cost-effectiveness of percutaneous RFA [12-13]. Unfortunately, both studies used a decision-analysis model in which the cost of RFA was an input data of the model. Gazelle et al. [12] used a single estimate of US$2287 which was based on 1998 Medicare reimbursement. Shetty et al. [13] used 2000 Medicare reimbursements as cost estimates: US$1413 for RFA performed in an outpatient setting and US$5656 for RFA performed in an inpatient setting.

Medicare reimbursement for the three RFA approaches has been updated over time [15]. In 2005, Medicare hospital

Table IV. – Diagnosis-related groups for RFA hospital stays.

<table>
<thead>
<tr>
<th>Diagnosis-related group</th>
<th>2005 Reimbursement per stay (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24M13Z-Malignancy of hepatobiliary system or pancreas &lt;24 hours</td>
<td>560</td>
</tr>
<tr>
<td>07M06V-Malignancy of hepatobiliary system or pancreas &gt;24 hours without CC</td>
<td>2752</td>
</tr>
<tr>
<td>07M06W-Malignancy of hepatobiliary system or pancreas &gt;24 hours with CC</td>
<td>4597</td>
</tr>
<tr>
<td>07C02V-Surgical procedures on liver or pancreas without CC</td>
<td>9084</td>
</tr>
<tr>
<td>07C02W-Surgical procedures on liver or pancreas with CC</td>
<td>11780</td>
</tr>
</tbody>
</table>

CC: complication or co-morbidity.

Table V. – Mean cost of hospital stay with RFA and mean reimbursement (€).

<table>
<thead>
<tr>
<th>RFA approach</th>
<th>Distribution of stays between DRGs</th>
<th>Mean reimbursement</th>
<th>Mean cost without IC</th>
<th>Mean cost with IC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Ia, DOS&lt;24 hours</td>
<td>Mainly 24M13Z*</td>
<td>560</td>
<td>1581</td>
<td>1581</td>
</tr>
<tr>
<td>Group Ib, DOS&gt;24 hours</td>
<td>2/3 of stays classified in 07M06V*</td>
<td>3367</td>
<td>3635</td>
<td>3824</td>
</tr>
<tr>
<td>Group II</td>
<td>Mainly 07C02V*</td>
<td>9084</td>
<td>6622</td>
<td>8194</td>
</tr>
<tr>
<td>Group III</td>
<td>1/2 of stays classified in 07C02V*</td>
<td>11780</td>
<td>10905</td>
<td>12967</td>
</tr>
</tbody>
</table>

*: DRG labels are given in table IV. Group Ia: percutaneous RFA in an outpatient setting, Group Ib percutaneous RFA in an inpatient setting, Group II: laparoscopic RFA, Group III: intraoperative RFA and surgical resection. DOS: duration of stay. DRG = Diagnosis-Related Group. IC = intensive care.
Cost of radiofrequency ablation in the treatment of hepatic malignancies

outpatient payment was US$ 2595 (€ 2159\textsuperscript{1}) for percutaneous RFA (1-day hospitalisation), US$ 3582 (€ 2980) for laparoscopic RFA and Medicare hospital inpatient reimbursement was US$ 9417 (€ 7833) for intraoperative RFA without complications or co-morbidities and US$ 21460 (€ 17851) for intraoperative RFA with complications or co-morbidities\textsuperscript{2}. In our study, there were 50% of stays with open surgery associated with either a complication or a co-morbidity. In this case, the mean Medicare reimbursement would be US$ 15438 (€ 12841). Comparing our results with Medicare reimbursement is however limited due to major differences between the French and US health care systems.

From a clinical standpoint, the rate of RFA complications (including deaths and extra-hepatic complications) was 5% in group I, 20% in group II and 20% in group III. These rates are consistent with those found in large series of patients. Mulier et al. described 7%, 10% and 32% of complications, respectively \[16\]. In a series of 124 intraoperative RFA procedures combined with a resection and 226 percutaneous RFA procedures, De Baere et al. reported an 11% complication rate including 6% of major complications \[17\]. Curley et al. reported 9% of complications in open RFA and 4% in percutaneous RFA \[18\] but there were no extra-hepatic complications in open RFA. Thus, their complication rate can be compared with our rate of major abdominal complications (9%).

Our study has some limitations. Firstly, our results are based on the experience of six referral centres: five comprehensive cancer centres and one teaching hospital. However, general public hospitals and private hospitals also perform RFA procedures. Secondly, sources of variability were numerous. We chose to cost resources with each centre’s unit costs rather than use mean unit costs. Our goal was to demonstrate the variability of unit costs between centres. This variability is known to be considerable and is dependent on many factors including the size of the institution, the number of staff employed, salary levels in the region, the level of research and teaching intensity. We verified that the variability of the costs of one day of hospitalisation per type of unit did not exceed what found in available statistics. Between the six centres, the coefficient of variation of the cost of one day of hospitalisation was 30%, 19% and 40% in a surgical unit, a general care unit and an intensive care unit, respectively. Different practice patterns between institutions were another source of variability. There was variability across centres in the RFA approaches (percutaneous, laparoscopic or intraoperative) and in the system used. Whenever possible, RFA was performed percutaneously because this is the less invasive procedure. Laparoscopic and open surgical approaches were considered when percutaneous RFA was impossible or when associated procedures were required (hepatic resection, other surgical procedures, or a laparoscopic staging work-up). Previous treatment guided the choice of the RFA approach. An open approach was contraindicated in patients with a limited liver reserve. In selected patients who had not previously undergone complex abdominal surgery, a laparoscopic approach was used instead of an open approach if the tumour position was favourable. Regarding the system used by the centres, it is noteworthy that the range of variation in the cost of the single-use needle electrode was quite large (from 200 € to 1400 € inclusive of VAT). Three factors have an impact on the unit cost. First, one of the four systems is clearly cheaper than the others. Second, with the other three systems, the price increases with the tumour size. Thus, to a certain extent, price variability could reflect the variability of lesion size. The bargaining power of purchasers also matters because prices are negotiated between hospitals and companies commercialising RFA systems. Finally, there was also variability in the type of care available in each centre. Two centres did not have an intensive care unit whereas the hospitalisation rate in an intensive care was 17% in the other centres. However, the study was not designed to evaluate the impact of all these factors (the RFA approach, type of needle electrode, unit cost differences) on the cost of RFA. Such a subgroup analysis would be unproductive due to the limited number of subjects and the absence of randomisation.

A third limitation is that we did not assess the cost-effectiveness of RFA. In 2006, it is difficult to perform a cost-effectiveness analysis based on reliable effectiveness data as randomised trials assessing the effectiveness of RFA are lacking. In HCC, a no treatment attitude is considered a lost chance compared to local destruction techniques that have been proven efficient (RFA, cryotherapy, chemo-embolisation, ethanol injection). RFA has been demonstrated to be superior to ethanol injection in small HCC \[19-20\]. However, there is a need for comparisons between RFA and cryotherapy or chemo-embolisation in a randomised controlled setting. A trial promoted by the European Organisation for Research and Treatment of Cancer is comparing modern chemotherapeutic agents plus RFA to chemotheraphy alone (CLOCC trial: Chemotherapy + LOCAL ablation versus Chemotherapy) in LM \[21\]. The primary endpoint is overall survival. As underlined by Poupon in an editorial of the Journal of Clinical Oncology \[22\], this trial may be the last opportunity to address the question of whether or not RFA is useful in LM. An economic evaluation is scheduled in the protocol.

In conclusion, we estimated the costs of hospital stays with RFA at € 1585 for percutaneous RFA in an outpatient setting, € 3824 for percutaneous RFA in an inpatient setting, € 8194 for laparoscopic RFA and € 12967 for intraoperative RFA combined with surgical resection. Reimbursement paid to hospitals under the French Prospective Payment System covers inpatient costs for RFA but is highly insufficient for percutaneous RFA performed in an outpatient setting.

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REFERENCES


\textsuperscript{1} Exchange rate 1 US$=€ 0.831806, retrieved March 6th 2006 from www.xe.com/ucc/fr.
Casemix: the type or mix of patients treated by a hospital or unit. The DRG classification can be used to synthesize the activity of a hospital. The case mix index is therefore the number of stays per DRG.

Classifications Commune des Actes Médicaux (CCAM): A new catalogue of all technical procedures in the medical and surgical specialties. This new classification replaces and unifies the Cdam and the NGAP classifications.

DRGs (Diagnosis-related Groups): classification system used in a case mix funding model. The classification system groups inpatient stays into clinically meaningful categories of similar levels of complexity that consume similar amounts of resources. The French classification consists of 776 DRGs broken down into 28 major diagnostic categories. The classification provides an exhaustive and a unique classification. The main variables determining the DRG orientation of a stay are the main diagnosis, the existence of a classifying procedure, associated co-morbidities or complications and age. A special program (Programme médicalisé des systèmes d’information — PMSI) made it compulsory for hospitals to set up information systems that take into account the diseases and management methods and to provide information on their medical activity.

ICR (indice de coûts relatifs; relative cost index): accounting unit of work which can be used to allocate the costs of medico-technical procedures between hospital stays. The ICR expresses the level of use of human and material resources for a given procedure. It is a relative index: if one procedure has an ICR of 100 and another of 50, this means that the first consumes on average twice as many human and material resources as the second. The Catalogue des Actes Médicaux (CdAM) was replaced by the Catalogue Commun des Actes Médicaux (CCAM).

National Cost Survey (Étude Nationale de Coûts): National database of costs per stay based on a sample of approximately 50 hospitals. The calculation of costs per stay is based on three major components: medical costs, medico-technical costs, structural costs and logistics costs.

Prospective Payment System: A method of reimbursement where payments are based on a predetermined fixed amount. The amount paid for a particular service is based on the classification system of that service (for example, DRGs for inpatient hospital services). The French prospective payment system is called Tarification A l’Activité (T2A). Vice versa, the French prospective payment system is called Tarification A l’Activité (T2A).
Appendix 1. Costing methodology details.

We carried out an ad hoc survey on a sample of institutions, by compiling the resources used and by valuing these resources by unit costs supplied by the institutions. Costing methodology is a mixture of micro-costing and the use of standard costs.

Resources collected for each patient:
- Number of bed days per type of unit (surgery, general care, intensive care, outpatient)
- Duration of intervention
- Type of RFA needle electrode
- Blood products
- Time spent in the recovery room
- All biological and imaging work-up
- All medications (except anaesthesia)

Unit costs for each type of resource:

Costs per day of hospitalisation per type of unit were computed using accounting data from each centre. All annual expenses except medications and blood products of the section of activity under consideration (respectively General care unit: section 923.021, Surgical unit: section 923.192, Intensive care unit: section 923.12 and 923.030, Outpatient unit: section 923.05) were divided by the number of days recorded for the section in the year. Unit costs include logistics and overheads in order to assess a full cost.

The opportunity cost of using the surgical unit for one hour was computed by costing specific resources (staff, needle electrode, anaesthesia medications and consumables). Other resources (logistics and overheads) were computed using expenses from accounting data and the number of hours the surgical unit is used in a year.

For staff, we considered a standard team consisting of 1 surgeon, 1 anaesthesiologist, 1 intern and 2 nurses. We used hourly full wages provided by the centres as unit costs.

The cost of an RFA needle electrode including VAT was the acquisition cost for a specific system in the centre under consideration. The cost varies from one system to another and among centres.

Blood products were valued using official prices.

For the recovery room, only staff costs were considered assuming a standard team (1 anaesthesiologist and 1 nurse).

Imaging work-up were valued using the number of ICRs per procedure and a unit cost of 6.1 € per ICR (see glossary) calculated based on the National Cost Survey data. The laboratory work-up was also valued using the B valued numbers per procedure (see glossary) and a unit cost of 0.19 € per B.

For medications, we used the acquisition cost per unit including VAT in the two centres which enrolled the most patients.

Standard costs

Expensive consumables (exclusively in the case of hepatectomy) are recorded in a database for each patient at the Institut Gustave Roussy. We calculated a mean cost of 1505 € for major hepatectomies and 780 € for partial hepatectomies. A standard list was established by the staff in the surgical unit at the Institut Gustave Roussy for inexpensive consumables. The list is available upon request from the first author.

Anaesthesia costs were assessed based on standard protocols used at the Institut Gustave Roussy. For a percutaneous RFA, a fixed cost of 31 € and a variable cost of 9 € per hour of anaesthesia were used. For one hepatectomy, a fixed cost of 32 € and a variable cost of 11 € per hour of anaesthesia were used.

Example: Cost calculation for a particular patient

Patient n°5 had a percutaneous radiofrequency ablation (group Ib) in centre n°1. The details of his consumption of resources and the corresponding costs are presented in the following table.

<table>
<thead>
<tr>
<th>Type of resources</th>
<th>Number of units</th>
<th>Unit cost (in €)</th>
<th>Resulting cost (in €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days in surgical unit</td>
<td>3</td>
<td>517</td>
<td>1551</td>
</tr>
<tr>
<td>Number of days in general care unit</td>
<td>0</td>
<td>615</td>
<td>0</td>
</tr>
<tr>
<td>Number of days in an intensive care unit</td>
<td>0</td>
<td>1146</td>
<td>0</td>
</tr>
<tr>
<td>Number of days in outpatient unit</td>
<td>0</td>
<td>485</td>
<td>0</td>
</tr>
<tr>
<td>Duration of intervention (in hours)</td>
<td>1.5</td>
<td>236</td>
<td>354</td>
</tr>
<tr>
<td>Duration of anaesthesia (in hours)</td>
<td>1.5</td>
<td>175</td>
<td>262</td>
</tr>
<tr>
<td>RFA needle electrode</td>
<td>Radiotherapeutics</td>
<td>838</td>
<td>838</td>
</tr>
<tr>
<td>Consumables for percutaneous RFA</td>
<td>Standard list per RFA type</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td>Post-anesthesia care unit (in hours)</td>
<td>1.78</td>
<td>111</td>
<td>198</td>
</tr>
<tr>
<td>Imaging work-up</td>
<td>20 ICR (See detail)</td>
<td>1 ICR=6.1</td>
<td>122</td>
</tr>
<tr>
<td>Biological work-up</td>
<td>150 B (See detail)</td>
<td>18=0.19</td>
<td>29</td>
</tr>
<tr>
<td>Medications</td>
<td>See detail</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>Blood products</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cost of the stay</td>
<td></td>
<td>3 424</td>
<td></td>
</tr>
</tbody>
</table>

*: Anaesthesia excluded.

Details of biological work-up:
- 2 complete blood count (2 x 50 B), 1 blood ionogram (40 B), 1 creatinine (10 B).

Details of imaging work-up: 2 abdominal ultrasound.

Details of medications:
- Hydroxyzin (Atarax®) 25 mg 1 0.07 0.07
- Amoxicillin, clavulanic acid (Augmentin®) 9 g 9 2.09 18.82
- Amoxicillin, clavulanic acid (Augmentin®) 2 g 4 0.34 1.37
- Bromazepam (Lexomil®) 6 mg 1 0.04 0.04
- Morphine chloride (Morpine®) 4 mg 4 0.41 1.63
- Paracetamol (Prodafalgan®) 10 g 5 1.46 7.32

29.26