Cost and cost-effectiveness of early inpatient rehabilitation after stroke varies with initial disability: the Czech Republic perspective

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The purpose of this prospective study was to determine whether the cost and cost-effectiveness of early rehabilitation after stroke are associated with the degree of initial disability. The data for cost calculations were collected by the bottom-up (micro-costing) method alongside the standard inpatient care. The total sample included 87 patients who were transferred from acute care to early rehabilitation unit of three participating stroke centers at the median time poststroke of 11 days (range 4–69 days). The study was pragmatic so that all hospitals followed their standard therapeutic procedures. For each patient, the staff recorded each procedure and the associated time over the hospital stay. The cost and cost-effectiveness were compared between four disability categories. The average cost of the entire hospitalization was CZK 114 489 (EUR 4348) with the daily average of CZK 5103 (EUR 194). The cost was 2.4 times higher for the immobile category (CZK/EUR: 167 530/6363) than the self-sufficient category (CZK/EUR: 6825/2614), and the main driver of the increase was the cost of nursing. The motor status had a much greater influence than cognitive status. We conclude that the cost and cost-effectiveness of early rehabilitation after stroke are positively associated with the degree of the motor but not cognitive disability. To justify the cost of rehabilitation and monitor its effectiveness, it is recommended to systematically record the elements of care provided and perform functional assessments on admission and discharge. 

*International Journal of Rehabilitation Research 43: 376–382 Copyright © 2020 The Author(s). Published by Wolters Kluwer Health, Inc.*

**Keywords:** community health services, costs and cost analysis, Czech Republic, neurorehabilitation, patient outcome assessment, stroke

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Received 18 June 2020 Accepted 1 September 2020

Introduction

Stroke treatment has changed remarkably in the last decade with the application of novel neurosurgical and neurological procedures and the establishment of specialized (comprehensive) stroke units that also include early rehabilitation (Hamann et al., 2016; Škoda et al., 2016; Powers et al., 2018; Pross et al., 2018; de Sousa et al., 2019). There is a general agreement that early rehabilitation is beneficial after stroke (Bernhardt et al., 2015b; Hamann et al., 2016; Coleman et al., 2017; Langhorne et al., 2017; Powers et al., 2018). Next to clinical evidence, this is supported by the results of animal experiments indicating that a narrow window of opportunity for reactive neurobiological recovery and repair may exist, and the optimum period for change could be early after stroke (Murphy and Corbett, 2009; Krakauer et al., 2012; Teasell and Hussein, 2016). The high-intensity rehabilitation therapy within the first 90 days is reported to be associated with a lower mortality risk than the low-intensity therapy among patients with mild to moderate stroke severity (Hsieh et al., 2018). However, the percentage of patients referred to early inpatient rehabilitation is still low (Chen et al., 2020).

The definition of ‘early rehabilitation’ differs; however, the 2008 European stroke treatment guidelines consider early rehabilitation when administered 20 or even 30 days after stroke (Hacker et al., 2008; Quinn et al., 2009), but already 6 years later, it decreased to 7 days after stroke (Lynch et al., 2014). Moreover, the A Very Early Rehabilitation Trial after stroke (AVERT) clinical trial investigated the efficacy of a ‘very early mobilization’ within 24 h of stroke onset (Bernhardt et al., 2015b; Langhorne et al., 2017). A comprehensive overview of this problem was published by Bernhardt et al. (2019). While the clinical aspects of the early rehabilitation have been quite frequently discussed, compare, for example,
the reviews (Bernhardt et al., 2015a; Coleman et al., 2017; Langhorne et al., 2017) or the guidelines (Winstein et al., 2016; Küçükdeveci et al., 2018; Powers et al., 2018), little is known about its cost and cost-effectiveness. The limited information was collected mainly during the AVERT trials (Tay-Teo et al., 2008; Sheppard et al., 2016; Gao et al., 2019). Simultaneously, several systematic reviews covering economic evaluations of the rehabilitation after stroke have been published (Brady et al., 2005; Tümmers et al., 2012; Chen et al., 2020). Chen et al. (2020) suggest that the rehabilitation ward is cost-effective in comparison with other options (rehabilitation without transfer to the rehabilitation ward, or no rehabilitation). Although Tümmers et al. (2012) recommended performing a cost analysis across different severities of stroke almost a decade ago, this information is still missing.

Early rehabilitation after stroke did not exist in the Czech Republic until 2015 when the stroke units were officially established (Ministry of Health of the Czech Republic, 2015). At present, there are 13 comprehensive cerebrovascular centers (consisting of neurosurgical, radiological, neurological and early rehabilitation units) and 32 stroke centers (neurological and early rehabilitation units). Patients are typically transferred to early rehabilitation units between 7 and 14 days after stroke, where they receive 3–4 h of multidisciplinary rehabilitation per day.

Our 2017 tri-center study determined the average costs of early rehabilitation after stroke to be CZK 114 489 (EUR 4348) for the entire hospitalization or CZK 5103 (EUR 194) per day (unpublished to date). To expand on this, the goal of this study is to determine whether the cost and cost-effectiveness of early rehabilitation are associated with the degree of initial disability. Such information is expected to be useful for hospital managers to decide about the content and organization of early rehabilitation after stroke, and for negotiating reimbursement with the regulators. On a broader scale, our approach and results would be informative for international comparisons of cost-effectiveness and organization of early rehabilitation after stroke.

Participants and methods

The data used here come from a national pragmatic study carried out in three hospitals (General University Hospital in Prague, Department of Rehabilitation Medicine; Masaryk Hospital in Ústí nad Labem, Rehabilitation Department; and University Hospital Ostrava, Clinic of Rehabilitation and Physical Medicine) from April to November 2017. The study was approved by the ethics committee of the General University Hospital in Prague. The inclusion criteria were stroke diagnosis (ischemic or hemorrhagic), hospitalization between 4 and 90 days, and no interruption in the early rehabilitation stay unless the treatment for complications occurred in the same hospital. A total of 87 patients were included in this study, and they were admitted to the early rehabilitation unit less than 70 days after stroke. The hospitals listed above contributed 29, 31 and 27 patients, respectively.

Data for cost calculation were collected by the bottom-up (micro-costing) method alongside standard patient care. The study was pragmatic so that all hospitals followed their standard therapeutic procedures. The staff recorded each procedure and the number of therapeutic units or time spent continuously with a patient on 10 treatment forms. The recorded data were transferred to 10 economic forms where each therapeutic unit or time spent was multiplied by the respective cost. Standard statistical analyses were performed using MS Excel and R applications.

Personal and clinical data were recorded on eight clinical forms and captured basic demographics, relevant dates (stroke onset, admission, transfer to the early rehabilitation unit and discharge), physician’s evaluation of functional abilities and categorization (see below), functional tests carried out by trained therapists (starting on day 3 of admission to the rehabilitation unit and then every 2 weeks). In this study, outcomes were assessed by the following functional tests: the Barthel Index (Mahoney and Barthel, 1965), Extended Barthel Index (EBI) (Prosigiel et al., 1996; Katona et al., 2015) and the functional independence measure (FIM) divided into the motor and cognitive subscales (Chumney et al., 2010). The EBI was developed to widen the utility of this scale by adding six cognitive items. Although some authors used the abbreviation EBI when referring to all 16 items together (Maritz et al., 2019), it is recommended to designate with EBI only the six cognitive items (DIMDI, 2018). To avoid any confusion, we use Barthel Index+EBI to denote the combined 16-item scale.

The above-mentioned categorization (hereinafter referred to as disability category) is on the basis of the Czech reimbursement scheme, Section 6 of the Czech Republic Decree No. 134/1998 Coll. (1998), and it applies to all inpatient facilities. The five disability categories are as follows: (1) self-sufficient, (2) partly self-sufficient, (3) requires an enhanced level of supervision, (4) immobile and (5) unconscious. Staff routinely assigns patients to these categories and can be assumed to have rich experience with this classification. The disability category was used as the independent variable to measure the degree of initial disability.

All cost data are given in Czech crowns (CZK) and Euro (EUR) using the 2017 Czech National Bank average exchange rate of EUR 1=CZK 26.330. The costs were calculated by the micro-costing (bottom-up) method (detailed methodology to be published in a separate article, unpublished to date). The cost-effectiveness ratios were calculated individually for each disability category as the average total cost of the hospitalization in the rehabilitation unit divided by the average incremental change in the outcome (end – beginning). This was done separately for Barthel Index, EBI, Barthel Index+EBI, total FIM, motor FIM and cognitive FIM, yielding six sets of cost-effectiveness values per each disability category.
Results

The age of 87 included patients was between 31 and 95 years (mean 70.5). Sixty-four patients (73.5%) were between 60 and 90 years, almost equally distributed in decades. The laterality in hemiparesis was balanced (left-side in 41 patients, right-side in 41 patients and no or unrecorded in 5 patients). The average length of hospitalization was 22.2 days.

The disability category (see Patients and Methods for the definition) was determined by the physician during the admission interview/examination. No patient was assigned to the unconscious category. Table 1 shows basic baseline data characterizing patient distribution to the categories and the respective initial and final average scores for Barthel Index and FIM. While the age was independent of the categories, both the length of hospitalization in the rehabilitation unit and the number of days between stroke onset and transfer to the rehabilitation unit grew from less to more disabled categories. Also, the scores of Barthel Index and motor FIM were associated with the categories, which was not found for EBI and cognitive FIM (only the patients in the fourth category showed visibly worse results).

Table 1 Distribution of patients across the four disability categories and their characteristics at the beginning of rehabilitation

| Disability category | 1 | 2 | 3 | 4 | Average |
|---------------------|---|---|---|---|---------|
| Number of patients  | 15| 27| 24| 21| 87      |
| Average age (years) | 65.7 (45–88)| 71.5 (31–90)| 71.9 (49–93)| 71.0 (41–91)| 70.5 (31–93) |
| Average length of hospitalization on rehabilitation (days) | 16.4 (9–40)| 19.1 (4–50)| 24.8 (11–50)| 27.5 (4–45)| 22.2 (4–59) |
| Average time from stroke onset to translation to rehabilitation unit (days) | 10.5 (4–22)| 12.6 (4–30)| 14.3 (6–34)| 27.1 (9–69)| 11 (4–69) |
| Barthel Index beginning | 88.7 (65–100)| 65.9 (15–100)| 57.1 (5–90)| 23.8 (0–65)| 57.3 (0–100) |
| Barthel Index end | 96.7 (80–100)| 82.6 (40–100)| 72.9 (20–100)| 44.5 (5–95)| 73.2 (5–100) |
| EBI beginning | 78.0 (40–90)| 72.4 (15–90)| 72.5 (20–90)| 48.8 (20–90)| 67.7 (15–90) |
| EBI end | 83.7 (65–90)| 76.1 (25–90)| 76.3 (15–90)| 57.6 (25–90)| 73 (15–90) |
| Barthel Index + EBI beginning | 166.7 (125–190)| 138.3 (40–185)| 129.6 (40–180)| 72.6 (25–155)| 124.9 (25–190) |
| Barthel Index + EBI end | 180.3 (160–190)| 158.7 (65–190)| 149.2 (60–190)| 102.1 (50–180)| 146.2 (50–190) |
| FIM beginning | 105.3 (83–123)| 86.0 (26–120)| 78.5 (21–114)| 48.3 (20–96)| 78.2 (20–123) |
| FIM end | 113.2 (92–125)| 100.1 (45–126)| 92.3 (26–122)| 61.3 (22–114)| 90.9 (22–126) |
| FIM + Motor beginning | 76.6 (55–91)| 58.7 (20–86)| 50.0 (14–80)| 28.9 (13–72)| 52.2 (13–91) |
| FIM + Motor end | 83.1 (69–91)| 71.5 (29–91)| 62.8 (16–90)| 39.5 (15–85)| 63.4 (15–91) |
| FIM – Cognitive beginning | 28.7 (15–35)| 27.3 (5–35)| 28.5 (7–35)| 19.4 (6–34)| 26 (5–35) |
| FIM – Cognitive end | 30.1 (16–35)| 28.6 (6–35)| 29.5 (10–35)| 21.8 (7–34)| 275 (6–35) |

EBI, Extended Barthel Index; FIM, functional independence measure.

Fig. 1

Average scores of Barthel Index + EBI and total FIM in the beginning and at the end of inpatient rehabilitation with the average improvement across the four disability categories. EBI, Extended Barthel Index; FIM, functional independence measure.
Figure 1 illustrates the average improvements in different categories in terms of Barthel Index+EBI and FIM. The same proportional change is representative of the increase in Barthel Index and motor FIM, whereas their cognitive parts did not differentiate between categories 1, 2 and 3. Both the initial and final scores were lower in more disabled categories. Thus, the disability categories as defined by the Czech reimbursement scheme proved valid for grouping patients according to the level of disability, which justifies their use as the independent variable in this study.

For the calculation of cost-effectiveness, we first examined the dependence of the costs and their components on the disability category. The cost data are presented in Table 2.

For calculating the cost-effectiveness ratios, we divided the average costs of early rehabilitation hospitalization by the average increase in Barthel Index, EBI, Barthel Index+EBI, total FIM, motor FIM and cognitive FIM from admission to discharge. Thus, the resulting cost-effectiveness ratio can be interpreted as the incremental cost-effectiveness ratio, which provides a standard comparison of the spent money effectiveness over the disability categories. All cost-effectiveness data are presented in Table 3. Since the cognition scores (EBI and FIM-cognitive) had only a small effect on the total results, we focused on the respective motor scores (Barthel Index and motor FIM) and the total scores (Barthel Index+EBI and total FIM). Figure 2 shows the cost-effectiveness ratio dependent on the disability categories for Barthel Index and FIM, indicating the same pattern for FIM and Barthel Index scores. Finally, Fig. 3 provides the breakdown of the cost-effectiveness results across different Barthel Index and FIM scores, expressed as the ratio to the category average.

The greatest cost-effectiveness (the smallest expense for achieving a one-point improvement in the functional score) was most often found in category 2 (partly self-sufficient) (i.e. the lowest value across four categories for all outcomes but EBI). The cost-effectiveness based on Barthel Index was similar for categories 1, 3 and 4, while increasing FIM by one point was the most expensive in category 4 (Table 3, last row last column).

Table 2  Average costs across disability categories

| Category | Number of patients | Costs per one patient-CZK (EUR) | Total costs per one patient – index (relation to the average costs in the first category) |
|----------|-------------------|-------------------------------|---------------------------------------------------------------------------------|
|          |                   | Total One-day | Personnel | Nursing | Therapeutic | Materials | Devices and aids | Drugs | Complement |
| 1        | 15                | 68825 (2614) 4283 (162.67) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2        | 27                | 85263 (3238) 5413 (171.40) | 1.239 | 1.100 | 1.313 | 0.943 | 1.817 | 1.123 | 4.942 | 4.010 |
| 3        | 24                | 129498 (4918) 5932 (203.27) | 1.882 | 2.441 | 3.993 | 1.302 | 7.269 | 1.278 | 3.797 | 2.064 |
| 4        | 21                | 167530 (6363) 6165 (234.14) | 2.434 | 3.514 | 6.178 | 1.559 | 14.732 | 1.399 | 5.163 | 2.237 |

Table 3  Cost-effectiveness ratios across disability categories and outcome measures

| Disability category | 1 | 2 | 3 | 4 |
|---------------------|---|---|---|---|
| C-Average cost (CZK) | 68825 | 85263 | 129498 | 167530 |
| EBI                 | 8.0 | 8603 | 16.7 | 5116 |
| Barthel Index       | 5.7 | 12075 | 3.7 | 23044 |
| Barthel Index+EBI   | 13.7 | 5024 | 20.4 | 4180 |
| FIM motor           | 6.5 | 10588 | 12.8 | 6661 |
| RM cognitive        | 1.4 | 49161 | 1.3 | 68587 |
| RM                  | 7.9 | 8712 | 14.1 | 6047 |

C/E values are comparable only in lines, not between different outcomes.

C, average cost for the disability category; C/E, cost-effectiveness ratio for the respective outcome; E, effect, i.e. outcome value; EBI, Extended Barthel Index; FIM, functional independence measure.

Discussion

The idea behind our research was that the costs grow with the degree of disability, which proved true; depending on the disability category, the cost increase was between 56 and 143% (Table 2). This does not fully project into cost-effectiveness figures. The inpatient rehabilitation proved to be most effective for partly self-sufficient patients (disability category 2), although it is closely effective also for self-sufficient patients (category 1) and those that require an enhanced level of supervision (category 3) (Fig. 2).

On the other hand, inpatient rehabilitation appears to be the least effective for the most severely disabled patients (disability category four), who are greatly dependent on others in activities of daily living. Not surprisingly, the worse the initial disability, the longer the time to improve to the point of plateau. They also have a lot of comorbidities and need more medication, more aids and sometimes
more therapists and nurses to assist with mobility. Some of them remain severely disabled, showing little to no improvement, and we have no reliable predictive markers to see it early after stroke (Winters et al., 2018). On the other hand, even a small improvement may mean a great difference in the quality of life for this group.

Our results also revealed which disability scales are the most suitable for economic analyses. The scales assessing motor skills (Barthel Index and motor FIM) are much more sensitive than cognitive counterparts (EBI and cognitive FIM). This is not surprising because, after stroke, motor impairments tend to be more common and
Conflicts of interest

There are no conflicts of interest.

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