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Original article

Maximizing rehabilitation outcomes in geriatric hip fracture patients: the impact of surgical variables

Oriana Amata[1], Erminia Ridolo[2], Valeria Costantino[1], Lorenzo Panella[1], Cristoforo Incorvaia[3], Antonello Valerio Caserta[1], Camilla Callegari[4]

[1]Department of Rehabilitation, ASST Gaetano Pini-CTO, Milan, Italy; [2]Allergy and Clinical Immunology, Medicine and Surgery Department, University of Parma, Parma, Italy; [3]Cardiac/Pulmonary Rehabilitation, ASST Gaetano Pini-CTO, Milan, Italy; [4]Department of Medicine and Surgery, Division of Psychiatry, University of Insubria, Varese, Italy

Abstract. *Background and aim:* Hip fracture is a major traumatic event with high mortality and disability rate. Its management in the acute setting and in the rehabilitation process is highly debated. This study evaluates the possible determinants of hip fracture rehabilitation outcome, among which surgical intervention type, weight-bearing status and hospitalization length. *Methods:* The data of 738 hip fracture patients, who completed rehabilitation process in our centre, were collected and patients' functional abilities at the time of admission and discharge were analysed. *Results:* It has been observed that functional recovery depends on several factors: the type of surgery, the post-operative course and related complications, the hospitalization time, the surgeon's techniques and expertise and the Orthopaedics Centre where the operation is performed. *Conclusions*: In conclusion, data integration in perspective of an individualised rehabilitation program appears crucial for the functional recovery of the hip fracture patient. (www.actabiomedica.it)

Key words: Functional recovery, Individual rehabilitation program, Surgical techniques, Hip risk, Weight bearing

Introduction

Hip fracture is a frequent traumatic event, especially in the geriatric population. Every year about 1.6 million individuals present with hip fracture (1) and this number is expected to increase up to 2.6 million case/year before 2025 (2). Physical rehabilitation is crucial for the recovery of the compromised function, particularly among older adults. Indeed, it is known that hip fracture is a major event for the patient physical and functional decline: in 1 year only 29% of the patients fully recover the ADL (Activity of Daily Living) and IADL (Instrumental Activity of Daily Living) that were present before the critical event (3), while 36% of patients die (4).

Medical comorbidities and their impact on rehabilitation outcomes of elderly patients with hip fracture is a critical area of research in geriatric medicine. A recent study (5) found that the presence of medical comorbidities, such as cardiovascular disease and diabetes, had a significant negative effect on patients' ability to regain autonomy after a hip fracture. Another study (6) also emphasized the need to address comorbidities in the rehabilitation of elderly patients with hip fractures, suggesting that a bio-psycho-social approach that addresses both medical and psychological factors can lead to improved outcomes in patients with osteoarthritis. This highlights the importance of considering and treating comorbidities in the rehabilitation process for elderly patients with hip fractures.

Considering the severity and the socio-economic burden caused by this event (expected to increase in the following years), we have asked ourselves how the surgical variables (operation type and weight-bearing status) and the post-operative course in terms of complications and hospitalization length may influence the patients' outcome. The aim was to identify an optimal path to minimize the impact of hip fracture on the healthcare systems and on the patient's quality of life.

According to the surgical procedure, the American Academy of Orhopaedic Surgeons (AAOS) guidelines of 2015 (7) indicate the intramedullary nail (IMN) as the preferred treatment for femoral intertrochanteric (both stable and unstable) and subtrochanteric fractures. In the formers, screw and plate osteosynthesis, it is also suggested. Total or partial arthroplasty is indicated for the dislocated femoral neck fractures. There is moderate evidence of better long-term outcome in case of total hip replacement in comparison with partial one. Finally, there is low evidence of the advantage of the cemented prosthesis over cementless one.

Regarding weight-bearing (WB) status following osteosynthesis of femoral intracapsular fracture treated with IMN, in a 2011 review (8) the authors affirmed that the evidence was not sufficient to determine the consequences of an early weight-bearing. In a 2019 study, it was observed that, independently from the fracture type and treatment, the WB status in the geriatric population were determinant for a loss of mobility and provided no advantage in comparison to an early WB (9). Furthermore, the correlation between the surgeon expertise and the mortality rate was evaluated in the literature (10), showing that there was no significant difference in terms of mortality during hospitalisation. However, the surgeon's expertise might influence the surgical procedure duration and the possible post-operative complications. In a 2005 Canadian study, the authors demonstrated a reduced mortality in the university teaching hospitals (11). The correlation between the number of hospitalisation days in a rehabilitation setting and the autonomy recovery was limited in other studies (12).

Our rehabilitation centre admits proximal third hip fracture patients transferred from different hospital structures of all the city. We have asked ourselves how much the surgeon's expertise and the WB restrictions after surgery, often due to legal implications, may be determinant in defining the functional recovery and the patient's autonomy outcome.

Material and methods

We made a retrospective longitudinal study.

All patients admitted to the Rehabilitation Department of our Centre between April 2019 and March 2020 for rehabilitation program following hip fracture, both traumatic and pathologic, were included in the study. Patients who died during hospitalization, those transferred to another hospital or those who signed voluntary discharge, patients with additional fractures, polytraumas and those patients with cerclage wiring fixation were excluded. The data of 738 patients were evaluated, 561 fulfilled inclusion criteria. Subsequently, the selected patients were stratified according to sex, operation type (synthesis with nail, endoprosthesis, screws, complete hip prosthesis), orthopaedics WB status (i.e. non-weight-bearing, toe-touch weight-bearing, partial weight-bearing, weight-bearing as tolerated), hospital of origin (identified as Hospital-1, Hospital -2, Hospital -3, Hospital -4, Hospital -5).

The following were the evaluated rehabilitation outcomes:

- Discharge NRS (Numerical Index scale) (13);
- Variation of Barthel Index (Δ BI): (discharge BI – admission BI) (14);
- Discharge BI (15);
- Barthel Index Effectiveness: discharge BI – admission BI /(100 – discharge BI +admission BI) x 100 (16);
- Rehabilitation Effectiveness Index (REI): (discharge BI – admission BI)/days of hospitalization (14).

Study aims

The aim of the study was the evaluation of the surgical intervention type, the WB status and the

functional outcome and their correlation. Furthermore, we evaluated hospitalization length, clinical course and functional recovery and we analyzed the correlation between the rehabilitation outcome and the hospital from which the patient was transferred, assuming there are different programs and surgical approaches in each centre.

Statistical analysis

Student-t test was used to compare groups, comparing the mean of the population positive for a given variable ± standard deviation (SD) and the mean of the population negative for a given variable. Pearson correlation coefficient was used to study the correlation among the different variables. The analysis was performed with SPSS (Statistical Package for Social Science, IBM SPSS Statistics, version 26 for Windows).

Results

Population

Among all the hip fracture inpatients, 561 were selected; 78% were female. Mean age was 81.3 years (SD 9.6). 50.4% of the patients underwent IMN osteosynthesis, 39.2% an endoprosthesis, 6.1% plates and/or screws and 4.3% underwent total hip replacement. 39.6% of the patients reached our rehabilitation centre with the indication to begin the walking training with partial weight-bearing (PWB), 35.5% weight-bearing as tolerated (WBAT), 21.5% toe-touch weight-bearing (TTWB) and, finally, 3.4% non-weight-bearing (NWB).

We identified 5 Orthopaedic centres of afference to our structure. 43.5% of patients were transferred from Hospital-1, 19.6% from Hospital -2, 6.8% from Hospital -3, 9.3% from Hospital -4 and 7.7% from Hospital -5; 13.1% of patients were transferred from other centres. The mean hospital length of stay in our ward was 29.6 days.

Correlation among surgical procedure type, weight-bearing status and functional outcome

The analysis of the correlation between surgical procedure and functional outcome, considering the mean values, showed a major BI variation (38.7±13.1 vs 32.4±16.6; P: 0.004) for the IMN osteosynthesis. The same procedure was also associated to a higher mean value of discharge NRS (2.5±1.8 vs 2±1.4; P: 0.021) than the hip endoprosthesis (1.5±1.3 vs 2.1±1.5; P: 0.045), which is also associated with a higher REI score (1.26±0.72 vs 1.13±0.6; P: 0.049) (Table 1).

In our study, we observed that the WBAT status is an advantage compared to TTWB and NWB. The patients with WBAT are associated with a lower mean value of discharge NRS (1.7±1.3 vs 2.1± 1.5, p 0.016) and a higher BI variation value (38±17.8 vs 32.1±16;

Table 1. Relation between surgical procedure type and outcomes.

	% Patients	Discharge NRS (mean ± SD)	Δ Barthel (mean ± SD)	Discharge BI (mean ± SD)	Effectiveness BI (mean ± SD)	REI (mean ± SD)
Intramedullary Nail	50.4%	2.5±1.8 vs 2±1.4; p 0.021	38.7±13.1 vs 32.4±16.6; p 0.004	p > 0.05	p > 0.05	p > 0.05
Endoprosthesis	39.2%	1.5±1.3 vs 2.1±1.5; p 0.045	p > 0.05	p > 0.05	p > 0.05	1.26±0.72 vs 1.13±0.6; p 0.049
Screws And Plates	6.1%	p > 0.05	p > 0.05	p > 0.05	p > 0.05	p > 0.05
Total Hip Replacement	4.3%	p > 0.05	p > 0.05	p > 0.05	p > 0.05	p > 0.05

NRS = Numerical Index scale, BI = Barthel index, REI = Rehabilitation Effectiveness Index, SD = standard deviation.

P: 0.003), a higher effectiveness BI value (79±72 vs 57±47; P: 0.009) and a higher REI score (1.4±0.9 vs 1.1±0.6; P: 0.003) (Table 2). Patients restricted to TTWB were associated to a higher discharge NRS (2.5±1.6 vs 2.0±1.4; P: 0.001) (Table 2). Finally, NWB patients were associated to a lower Δ BI value (25.1±17.8 vs 33.2±16.3; P: 0.034) and to a lower REI score (0.9±0.5 vs 1.2±0.6; P 0.033) (Table 2).

Correlation among days of hospitalisation, clinical course and functional recovery

A low correlation among days of hospitalization, Δ NRS (Pearson 0.19; P < 0.001), Δ BI (Pearson0.27; P < 0.001) (Figure 1) and Effectiveness BI (Pearson 0.22; P < 0.001) has been observed (Figure 2). Moreover, it has been identified that the hospitalisation is shorter in the patient operated with total hip replacement (24.4±6.7 vs 29.6±8.6; P: 0.007).

We studied how the post-operative clinical course and the most common surgical procedure-related complications may influence the rehabilitation process. From our analysis we observed that the absence of complications is linked to a lower discharge NRS (1.9±1.5 vs 2.2±1.4; P: 0.003) and a higher discharge BI value (74±21 vs 70±22; P: 0.034). A hospitalisation complicated by anaemia is associated to a higher discharge NRS score (2.3±1.4 vs 1.8±1.4; P < 0.001); the presence of a post-operative infection is linked to a lower discharge BI value (60±26 vs 72±21; P: 0.001) and a shorter hospitalisation in comparison to patients without infections in the post-operative course (25±9 vs 30±8; P: 0.002). A post-operative course characterised by agitation is associated to a lower discharge BI mean value (60±21 vs 72±21; P: 0.006).

Correlation differences according to provenance hospital

Assuming that in each hospital the surgical expertise is different, we studied how this may influence the rehabilitation outcome. It has been observed a better functional recovery in the patients coming from Hospital-2 in comparison to those coming from other hospitals in terms of Δ BI mean value (37.6±16.9 vs 31.6±16; P: 0.001), Effectiveness BI value (75±65 vs 56±48; P: 0.004) and REI score (1.3±0.7 vs 1.1±0.6; P: 0.002).

A higher discharge BI value is associated to Hospital -1 (75±20 vs 68±22; P < 0.001).

Patients coming from Hospital -3 have a lower Δ BI (26±15 vs 33±16; P: 0.006), a lower Effectiveness BI value (42±36 vs 61±53; P: 0.026) and a lower REI score (0.86±0.46 vs 1.18±0.64; P: 0.002). Patients transferred from Hospital -5 are associated to a lower discharge BI value (61±23 vs 72±21; P: 0.002). Hospital -4 does not have statistically significant variations.

Table 2. Relation between weight-bearing restriction and outcomes.

	% Patients	Discharge NRS (mean ± SD)	Δ BI (mean ± SD)	Discharge BI (mean ± SD)	Effectiveness BI (mean ± SD)	REI (mean ± SD)
Weight-Bearing As Tolerated	35.5%	1.7±1.3 vs 2.1± 1.5, p 0.016	38±17.8 vs 32.1±16; p 0.003	p > 0.05	79±72 vs 57±47; p 0.009	1.4±0.9 vs 1.1±0.6; p 0.003
Partial Weight-Bearing	39.6%	p > 0.05	p > 0.05	p > 0.05	p > 0.05	p > 0.05
Toe-Touch Weight-Bearing	21.5%	2.5±1.6 vs 2.0±1.4; p 0.001	p > 0.05	p > 0.05	p > 0.05	p > 0.05
Non- Weight-Bearing	3.4%	p > 0.05	25.1±17.8 vs 33.2±16.3; p 0.034	p > 0.05	p > 0.05	0.9±0.5 vs 1.2±0.6; p 0.33

NRS = Numerical Index scale, BI = Barthel index, REI = Rehabilitation Effectiveness Index, SD = standard deviation.

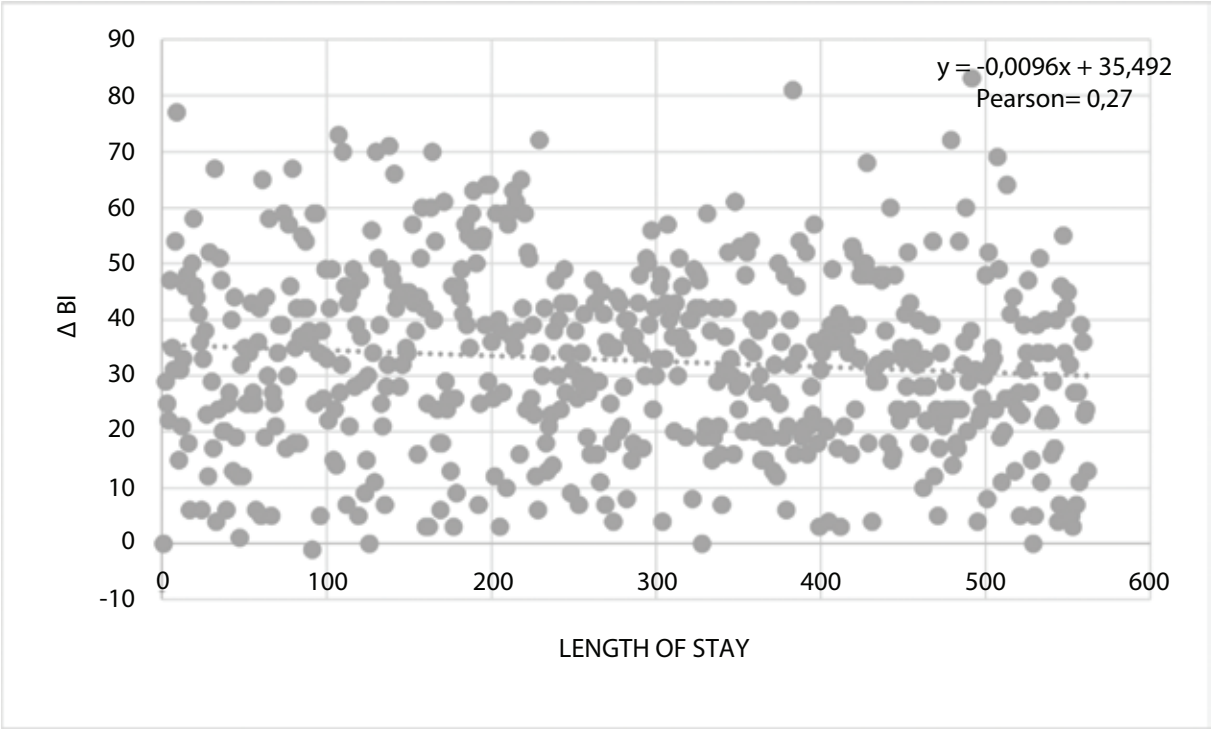

Figure 1. Correlation between Length of stay and Δ Barthel Index.

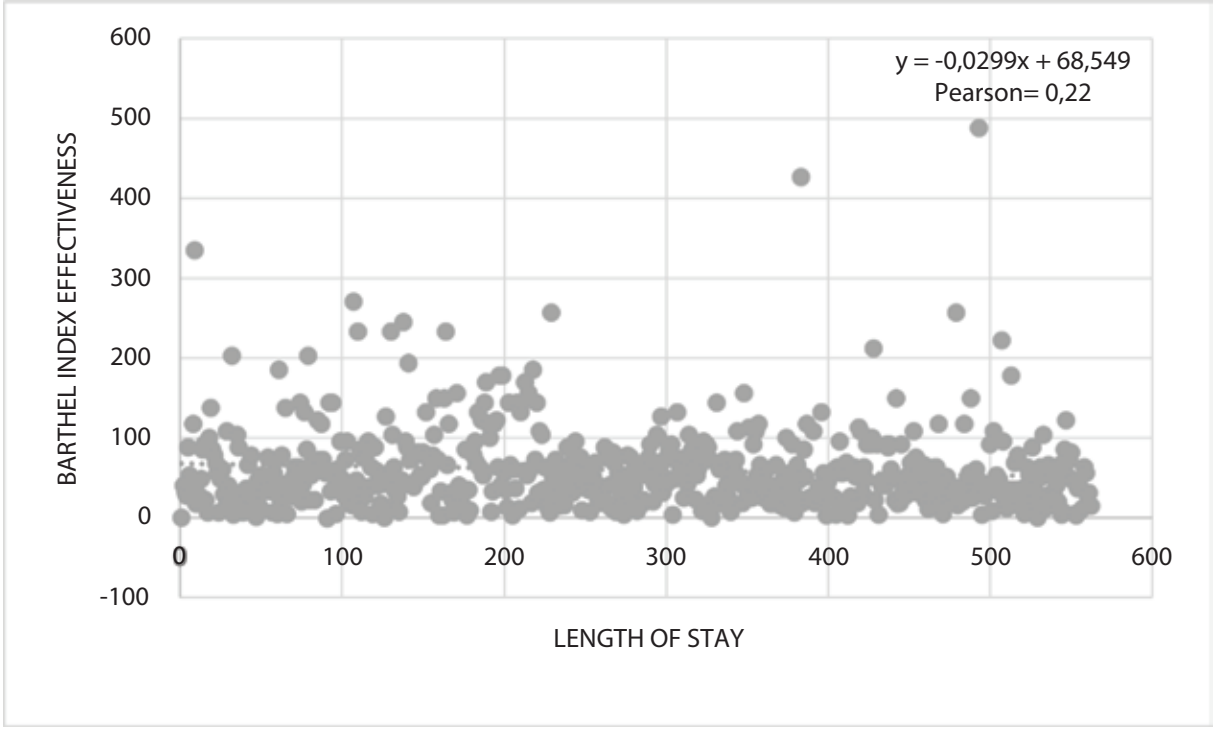

Figure 2. Correlation between Length of stay and Barthel Index Effectiveness

Discussion

Correlation among surgical procedure type, weight-bearing status and functional outcome

Surgical procedure type with its relative influence on outcome has been the first surgical variable studied. We have observed a better recovery in the hip fracture patients operated with IMN in comparison to endoprosthesis, total hip replacement and screws and plates osteosynthesis (Table 1). Our result is similar to that reported in a recent study (17) in which it has been observed a better outcome in patients with IMN osteosynthesis in comparison to those with endoprosthesis, although Harris Hip score was used. The same result was demonstrated by a less recent study (18). In a 2019 study (19), the authors affirmed a better initial recovery of the ADL in the patients with an endoprosthesis following hip fracture, but at 6 months following the operation, the recovery outcome was similar to the patients with IMN.

Concerning pain evaluation, patients with endoprosthesis have been discharged with a less severe pain. This result is in line with a recent study (20), although its authors compared endoprosthesis only to screws and plates osteosynthesis. Other less recent studies showed more severe pain on discharge in patients with IMN surgery (18, 21, 22). A 2008 study highlighted less severe pain in patients with IMN in comparison to the patients with endoprosthesis, both on discharge and at 1 year, although considering only the non-displaced hip fracture treatment (23).

In the literature the WB restriction following hip fracture osteosynthesis is a controversial. Some studies (8) suggest NWB status immediately after surgery, especially in patients with IMN. In our study, we have observed a better recovery rate in the patients with WBAT from the admission in the ward in comparison to the patients with TTWB or NWB. Our result is in line with that of Warren et al. in which moreover, it was observed that the patients with IMN osteosynthesis with an early WB status have a shorter hospitalization stay than those with endoprosthesis or screws and plates osteosynthesis (24). Among our patients with early WB, we did not identify any hospitalization length advantage in the patients with IMN osteosynthesis in comparison to endoprosthesis or screws and plates osteosynthesis. Our data are in also accordance with a recent 2019 study (9), in which it was highlighted the disadvantage of WB restriction in terms of mobility, rather than the advantage of an early WB. Finally, in our data it has been observed a more severe pain on discharge in patients with a TTWB and a lower improvement of the BI score in the NWB patients.

Correlation among days of hospitalisation, clinical course and functional recovery

We have investigated how the days of hospitalisation may influence the functional recovery. It has been shown that there is a minimal correlation: with longer recovery time, further autonomy improvement is limited, although statistically significant. From our data it has emerged that the hospitalisation length is similar among the patients who underwent IMN, endoprosthesis or screws and plates osteosynthesis, while it is shorter in the patients who underwent total hip replacement.

In Tang et al. study, it was described a mean hospitalisation length shorter for those patients with IMN compared to endoprosthesis, despite of the fact that the latter allows an earlier mobilisation and limited WB restrictions (18). It is well-known that IMN osteosynthesis is associated with a lower amount of blood loss and a shorter hospital stay in the orthopaedic ward, with an infection risk similar to that of the other hip fracture surgical procedures (18). Furthermore, it was demonstrated that the endoprosthesis operation is associated to a higher CIRS (Cumulative Illness Rating Scale) score in the post-operative setting (19).

We also tried to evaluate how the most frequent post-operative complications impact on discharge outcome in our rehabilitation ward. As expected, we observed that the patients with a regular post-operative course have a better pain management and a higher BI score compared to those with at least 1 complication. Moreover, the presence of post-operative anaemia is significantly associated to a higher discharge NRS score. In a 2004 study, it was observed a correlation between post-operative anaemia and a longer

hospitalisation time in hip fracture patients, while it did not seem to influence the functional recovery (25). In the literature there is no data about pain and anaemia correlation.

The presence of a post-operative infection is linked to a lower discharge BI score and a shorter hospitalisation; this may be explained by the fact that the patients stay longer in the provenance ward, where they begin rehabilitation programs (26).

Correlation differences according to provenance hospital

In our study we also wanted to evaluate how the surgical expertise may influence the functional recovery. As already mentioned, it has been hypothesised that in each hospital of origin there were different surgeons with different surgical approaches. Our analysis shows that patients transferred from Hospital-2 had higher mean scores of Δ BI, Effectiveness BI and REI compared to the other hospitals and, in contrast, how the patients transferred from the orthopaedic ward of Hospital -3 had lower mean scores. Given the same admission BI and considering the data of the patients coming from Hospital-1 and Hospital-3, we have observed how the formers seem to have a better outcome compared to the latter, although without statistical significance (p 0.076). In general, coming from the Hospital-1 results to be an advantage in terms of abilities recovery on discharge (75±20.16 vs 69±22.1, p < 0.001) (Table 3). These differences may come from the surgical variables, even though other factors (e.g., post-operative medico-nursing assistance and/or the early implementation of physiotherapy treatment in the orthopaedic ward) may play a role.

Conclusions

In conclusion, we have observed that the positive predictive factors influencing the final outcome are the IMN osteosynthesis, although with a lower pain management on discharge, no or limited WB restrictions, longer hospitalisation and, possibly, the hospital of provenance. These data should be determinant both for the choice of the type of surgery and for the rehabilitation team in order to personalise treatments.

Surely, the sample size and the wealth of collected data are strong points of our study; a further step forward may take a cue from the impossibility to categorise the patients based on the fracture type, which is possibly a weak point of our study. Moreover, there is no information about the type of assistance and treatment differences among the various hospitals in the period between the surgical intervention and the admission in our ward.

We strongly believe in the importance of data integration in perspective of an individualised rehabilitation program. Nonetheless, it would be interesting, even though complex, to share the surgical indication protocols, taking into consideration that there are differences among the types of surgical interventions in terms of functional outcomes.

Conflict of Interest: The authors report no conflicts of interest in this work. Each author has no commercial associations that might pose a conflict of interest in connection with the submitted article.

Ethic Committee: Since the study is a retrospective observational investigation, an informed consent was not required. Data

Table 3. Correlation between provenance Hospital and rehabilitation outcomes.

	Discharge BI	Δ BI	Effectiveness BI	REI score
Hospital - 1	75±20 vs 68±22; p <0.001	p value>0.05	p value>0.05	p value>0.05
Hospital - 2	p value>0.05	37.6±16.9 vs 31.6±16; p 0.001	75±65 vs 56±48; p 0.004	1.3±0.7 vs 1.1±0.6; p 0.002
Hospital - 3	p value>0.05	26±15 vs 33±16; p 0.006	42±36 vs 61±53; p 0.026	0.86±0.46 vs 1.18±0.64; p 0.002
Hospital – 4	p value>0.05	p value>0.05	p value>0.05	p value>0.05
Hospital – 5	61±23 vs 72±21; p 0.002	p value>0.05	p value>0.05	p value>0.05

BI = Barthel index, REI = Rehabilitation Effectiveness Index, SD = standard deviation.

were analyzed anonymously. All personally sensitive information contained in the database used for this study was previously de-identified according to the Italian legislation (D.L. 196/2003, art. 110, -24 July 2008 art. 13). The study was carried out in accordance with the Declaration of Helsinki (with amendments) and Good Clinical Practice. As data were made anonymous and unidentifiable, the Ethical Review Board Ethics Committee consulted prior to the beginning of the study, has confirmed that, as it was a retrospective study, it did not need authorization from the Board.

Author Contribution: OA contributes in conceptualization of the study, investigation, data acquisition, data analysis and interpretation, writing - original draft, writing - review and editing. EA and CI carried out research methodology, validation, interpretation, and performs formal analysis, software, and review and editing the manuscript's draft. VC and AC contributed to the data acquisition, analysis, and interpretation, as well as reviewing and editing the manuscript. LP and CC played a role in supervision and contributed to the project administration. All authors play a role in writing - review and editing of manuscript.

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Correspondence:
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Oriana Amata, MD
Department of Rehabilitation, ASST Gaetano Pini-CTO, Milan, Italy.
Via Isocrate,19 - Milan, 20126 Italy
E-mail: amata.oriana@gmail.com
ORCID number: 0000-0002-9585-5428