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Original article

Impact of DRG billing system on health budget consumption in percutaneous treatment of mitral valve regurgitation in heart failure

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Abstract

Objective:
Percutaneous correction of mitral regurgitation (MR) by MitraClip (Abbot Vascular, Abbot Park, Illinois, USA) trans-catheter procedure (MTP) may represent a treatment for an unmet need in heart failure (HF), but with a largely unclear economic impact.

Research design and methods:
This study estimated the economic impact of the MTP in common practice using the disease-related group (DRG) billing system, duration and average cost per day of hospitalization as main drivers. Life expectancy was estimated based on the Seattle Heart Failure Model. Quality-of-life was derived by standard questionnaires to compute quality-adjusted year-life costs.

Results:
Over 5535 discharges between 2012–2013, HF as DRG 127 was the main diagnosis in 20%, yielding a reimbursement of €3052.00/case; among the DRG 127, MR by ICD-9 coding was found in 12%. Duration of hospitalization was longer for DRG 127 with than without MR (9 vs 8 days, $p<0.05$). HF in-hospital management generated most frequently deficit, in particular in the presence of MR, due to the high costs of hospitalization, higher than reimbursement. MTP to treat MR allowed DRG 104-related reimbursement of €24,675.00. In a cohort of 34 HF patients treated for MR by MTP, the global budget consumption was 2-fold higher compared to that simulated for those cases medically managed at 2-year follow-up. Extrapolated cost per quality-adjusted-life-years (QALY) for MTP at year-2 follow-up was ∼€16,300.

Conclusions:
Based on DRG and hospitalization costing estimates, MTP might be cost-effective in selected HF patients with MR suitable for such a specific treatment, granted that those patients have a clinical profile predicting high likelihood of post-procedural clinical stability in sufficiently long follow-up.

Introduction

Congestive heart failure (HF) is one of the most common cardiovascular disorders worldwide posing significant economic burden[1–5], with an estimated annual cost as high as 39 billion USD, and with a cost per quality adjusted life-year (QALY) of ∼€39,000[6]. HF is often associated with mitral valve regurgitation (MR)[7–11], in particular among those in older age[7,8]. In HF, MR may be associated with higher likelihood of hospitalization, and potentially with poor outcome[11–16]. The main cost in HF management is driven by recurrent hospitalization, particularly in the presence of MR[1].

Cardiac surgery is the gold-standard treatment for significant MR[15]. However, surgical treatment of MR in HF may be challenging[16], particularly in the sub-group of patients with older age and co-morbidities. Moreover, heart

surgery-related risk of major events increases significantly with older age and co-morbidities[17]. Furthermore, in functional MR in systolic HF, surgical restoration of the valvular function may be less beneficial than expected in relatively long follow-up, in particular in terms of mortality rate and functional status[18,19]. Those may be the reasons why a significant proportion of HF patients with severe valvular disease are denied surgery[7,16]. The rate of under-treatment of MR may be as high as 50% and more among HF with symptomatic MR[20]. In contrast, medically-managed HF patients with significant MR may have poor outcome, a mortality rate as high as 20% and 50% by year-1 and year-5 follow-ups, and a rate of hospitalization up to 90% within year-5 follow-up[16].

Recently, a safe and feasible novel approach has been proposed and validated for percutaneous treatment of symptomatic MR and perceived high cardiac surgery risk, the so called MitraClip (Abbott Vascular, Abbot Park, Illinois, USA) trans-catheter procedure (MTP)[21–28]. However, percutaneous treatment of significant MR in advanced HF may be associated with a further increased economic burden in HF management. Nevertheless, recent economic evaluations based on data from randomized trials suggested that MTP may be cost-effective compared to the medical approach[29,30]. Estimated costs of treatments of coronary heart disease, HF, and arrhythmias have costs per QALY ranging between 22.000–50.000 USD, or €17,000–39,000[6] at the actual currency exchange rate. Cost-effectiveness and cost-utility of MTP in the 'real world' remain largely unclear.

In the present collaborative study, we explored the impact of the diagnosis-related group (DRG) billing system, and of the costs for hospitalization length, as main drivers of the economic burden associated with hospital-based management of HF, with focus on MR as co-morbidity, and treatment by MTP[21–28]. For analyses purposes, firstly, in a large administrative data-set, we explored the relationship between DRG-based reimbursement and costs of hospitalization in the case of medically-managed HF, as defined by discharges allowing billing by DRG 127, with focus on the impact of MR on hospitalization length. Second, we evaluated in a specific cohort the DRG-based and hospitalization length costs associated with MR treatment by MTP. Finally, we explored costs per QALY in HF patients who met selection criteria for MTP[21–28], and estimated in that specific cohort the costs for medically-managed HF in the presence of untreated MR considering a follow-up of 2 years.

Patients and methods

Discharges documents for classification and billing purposes ('*Scheda di Dimissione Ospedaliera*', SDO) from the 'San Giuseppe Moscati' Hospital released during years 2012 and 2013 served to build an economic scenario considering standard information on: rate of discharges with HF as main diagnosis yielding the DRG Code 127; the duration of hospitalization for HF patients with and without concomitant mitral regurgitation, as defined by international classification of diseases-9th version (ICD-9) = 4240. To be emphasized, for administrative and reimbursement purpose, co-morbidities are reported only when impacting clinical management, for instance causing prolonged hospital stay or needs for high-cost diagnostic tools and treatments. The national-based outcome programme (*programma nazionale esiti*, PNE) managed by the National Agency for Regional Health Care System (*Agenzia Nazionale per i Servizi Sanitari Regionali*, AGE.NA.S.) was used as a data source for exploring morality rate and re-admissions within 30 days from discharge. Subsequently, the model was tested on data from a cohort of HF patients with symptomatic MR treated by the MTP (independent data provided by the 'San Giovanni di Dio e Ruggi D'Aragona' University Hospital, Salerno, Italy). DRG billing data were derived from the Regional Health Care Agency (Agenzia Regionale Sanitaria della Campania, ARSAN). Patient selection for MTP followed standard criteria as reported previously[22,25]. Quality-of-Life (QoL) was measured before and after the MTP (up to year 2 follow-up) and used for generating QALY comparative analyses[31–33]; cost per QALY was estimated on a 2-year based follow-up considering DRG-related billing, deficit (if any), and costs for recurrent hospitalizations, and divided by the 'utility index'. Long-term global economic burden was also extrapolated based on mean life expectancy in the MTP cohort by the Seattle Heart Failure Model[34] using average age, gender, HF functional class New York Heart Association, average left ventricular ejection fraction, pharmacological and device-based treatments.

Results

Between 2012–2013, the 'San Giuseppe Moscati' Hospital (Avellino, Regione Campania, Italy) generated 5535 SDO for the DRG billing system. Among those, 20%, or $n = 1107$, were for heart failure/cardiac shock (DRG 127), with a major contribution by non-hypertensive heart failure (ICD-9 code 428.x, 96%). In the period, MR as ICD-9 code 4240 was present on 4.7% of the total SDO, and, in particular, in 12% of those yielding DRG 127. On average, the duration of hospitalization for DRG 127 was 8 ± 7 days (median = 7, range = 1-44), and was longer in the presence (9 ± 6 days) than in the absence (8 ± 5 days, $p < 0.02$) of MR.

As reported in Table 1, considering the reimbursement for DRG 127 fixed by the regional Authority (ARSAN) at €3052.00, deficit per clinically-managed hospitalization

Table 1. Differences between DRG billing and average cost of hospitalization, the latter as a function of hospitalization length and cost per day as a proxy for clinical complexity. DRG 127 reimbursement = €3052.00.

Duration of hospitalization, days	Theoretical cost per day of hospitalization, in Euros							
	450	500	550	600	650	700	750	800
3	1702	1552	1402	1252	1102	952	802	652
4	1252	1052	852	652	452	252	52	−148
5	802	552	302	52	−198	−448	−698	−948
6	352	52	−248	−548	−848	−1148	−1448	−1748
7	−98	−448	−798	−1148	−1498	−1848	−2198	−2548
8	−548	−948	−1348	−1748	−2148	−2548	−2948	−3348
9	−998	−1448	−1898	−2348	−2798	−3248	−3698	−4148
10	−1448	−1948	−2448	−2948	−3448	−3948	−4448	−4948
11	−1898	−2448	−2998	−3548	−4098	−4648	−5198	−5748
12	−2348	−2948	−3548	−4148	−4748	−5348	−5948	−6548
13	−2798	−3448	−4098	−4748	−5398	−6048	−6698	−7348
14	−3248	−3948	−4648	−5348	−6048	−6748	−7448	−8148
15	−3698	−4448	−5198	−5948	−6698	−7448	−8198	−8948

Data in the table are in Euros. Negative data means that costs exceed the reimbursement, generating a deficit per single case managed, as a function of the hospitalization length and average costs per day of hospitalization. DRG-related reimbursement and cost per day of hospitalization impact the estimates, which may vary in different regions of Italy and, furthermore, in different Countries.

Table 2. Estimates of global budget consumption based on the number of hospitalizations per year, for an average case of DRG 127 with hospitalization length of 9 days, with an average cost of €500 per day of hospitalization.

Given average case assuming a duration of hospitalization of 9 days and a cost of 500 Euros per day of hospitalization		Theoretical number of DRG 127/year		
		100	150	200
Number of hospitalizations per patient-year	Deficit generated as difference between DRG 127 billing and costs estimated for the given average case	Global budget consumption as: DRG127 billing + Deficit per number of cases/year per number of hospitalizations/year		
2	−€2896.00	−€283,494.00	−€428,294.00	−€573,094.00
3	−€4344.00	−€425,241.00	−€642,441.00	−€859,641.00
4	−€5792.00	−€566,988.00	−€856,588.00	−€1,146,188.00
5	−€7240.00	−€708,735.00	−€1,070,735.00	−€1,432,735.00

Global economic burden is reported as a function of the number of hospitalizations per case-year, global hospitalization costs per case as DRG billing plus deficit for the average case, computing the theoretical global budget consumption based on a number of cases per year (100, 150, and 200 in the simulation reported). DRG-related reimbursement and cost per day of hospitalization impact the estimates, which may vary in different regions of Italy, and furthermore in different Countries.

increases roughly in relation to the length of hospitalizations and to the theoretical cost per day of hospitalization as a proxy for clinical complexity. As shown in Table 2, global health budget consumption for medically-managed HF patients is highly dependent on the number of hospitalizations per case-year, with a significant impact on the duration of hospitalization and the cost of hospitalization per day, both also influenced by clinical complexity of single cases.

Data from the MTP-centre ('San Giovanni di Dio e Ruggi d'Aragona' Univeristy Hospital, Salerno) reported 1.8 hospitalizations per patient-year in HF patients with significant MR candidates to MTP; data were consistent with those from a different population source of patients with advanced HF[35] treated in a different hospital of the 'Campania' Italian region. Therefore, we expected the cohort of patients who actually underwent MR correction by MTP to generate a DRG-based budget consumption of ∼€7000.00 per case-year if just treated medically. According to data available from the MTP-center, those HF patients reported a low QoL (mean value = 0.40) before MR correction. Therefore, the cost per QALY, based on 2-years of follow-up simulated with stable QoL for the cohort of HF with significant MR managed medically, was estimated to be as high as ∼€17,500.00, without accounting for extra-hospital costs.

Percutaneous correction of MR can be reimbursed based on DRG 104 (interventions on heart valves with cardiac catheterization, reimbursement fixed at €24,675.00). Complete devices costs is estimated at €21,000.00, approximately, including the device for inter-atrial septal puncture and additional costs for cath-

lab setting; hence, the procedure may be covered by the hypothetical DRG 104 reimbursement. According to data from the 34 MTP performed between 2012–2013, MR correction was associated with a significant improvement in QoL, which increased from 0.40 to 0.78 ($p < 0.01$, Student *t*-test for paired data) by year-2 follow-up. Cost per QALY for MTP by year-2 follow-up was estimated at ~€16,350.00 (cost per case set at €25,500.00 considering hospitalization length of 9 days, or €4500.00, to be added to a device cost of €21,000.00).

As reported in Table 3, the cohort undergoing MR correction by the MTP system absorbed a budget of ~€868,000.00 in 2 years, considering a post-MTP rate of re-hospitalization of 10%/year. In fact, seven re-hospitalizations were censored post-MTP in 2 years in four patients, yielding approximately a 10% re-hospitalization rate per patient-year follow-up. The center running the MTP-program also censored three fatal events (two cardiac and one non-cardiac) in 2 years, none of which were within 30-day from post-procedural discharge. Costs estimates for the same cohort of 34 HF patients with MR, but managed medically, considering 1.8 hospitalizations per patient-year with a mean hospitalization duration of 9 days, yielded an estimated global economic burden (DRG 127 billing plus deficit times hospitalizations/years) of ~€551,000.00 in 2 years. Therefore, the budget absorbed by the MTP program in 2 years was 2-fold higher than the one estimated by simulating for the same cohort of HF with MR a medical management with a number of hospitalizations/year/case for a comparable follow-up. Projecting costs for longer follow-up, as based on mean life expectancy of 8 years as predicted for the 34 patients by the Seattle Heart Failure Model, the budget absorbed by the 34 HF patients with MR medically-managed could rise to €2,203,200.00; the estimate assumes fixed conditions in terms of hospitalization rate/year, cost per day of hospitalization, mean hospitalization length per case. Even reducing the cohort size by estimated mortality rate at 5%, 9%, and 23% by year-1, year-2, and year-5 follow-up, respectively, according to the Seattle Hear Failure Model, the global burden on the health budget of the cohort of HF with MR medically-managed may exceed that for MTP in a few years.

Discussion

Our costing model is consistent with the notion that HF is an important determinant of health budget consumption. In addition, based on the DRG-related billing system defined by our regional health agency, DRG 127-related reimbursement was unable to cover estimated global costs for hospital management in almost half of the cases. This may be particularly true for HF with associated MR due to the higher likelihood of longer duration of hospitalization, as well as recurrent hospitalizations. Of note, for DRG-related reimbursement, only significant co-morbidity reporting is allowed, so that our results may not apply to all HF patients with MR, but to those with significant impact of MR on hospital management. While the model employed for estimating costs and margins may be generalized, findings may vary by health organizations, DRG-billing system, and costs per day of hospitalization, and be valid for a specific sub-set of HF patients with MR suitable for MTP treatment.

Our data are consistent with recent analyses suggesting that MTP can be cost-effective[29,30]. However, at variance with previous data[29,30] based on controlled randomized trials, we used data from the 'real world' of hospital activity, considering average clinical cases and the economic burden generated by the DRG reimbursement system and hospitalization length. For the perspective of the public health system, our analyses suggests that a MTP-program may be cost-effective for the given DRG-related billing rate and costs in a clinical scenario in which complete clinical stabilization and significant reduction of the re-hospitalization rate are sustained for 2 years or more. Nevertheless, beneficial impact of MTP on HF persisting for 2 years or more needs to be demonstrated. On the matter, results from analyses on year-4 follow-up in the EVEREST II trial can be considered promising but not conclusive[36]. Furthermore, cost-effectiveness analyses may need to consider emerging data reporting that the rate of valvular replacement after MTP for persistent significant MR can be as high as one in five patients, essentially within the first year of follow-up[36]. Interestingly, anterior leaflet pathology predicted need for mitral valve replacement both in the MTP and the mitral valve repair arms[37]. Moreover, different health system organizations, DRG-billing rate, and costs per day of hospitalizations may impact cost-effectiveness analyses.

Reduction of recurrent hospitalizations and reduction of hospitalization length are important targets for reducing health budget consumption in HF. In patients with advanced HF who underwent MTP, recurrent hospitalization rate and all-cause mortality rate may reach 31% and 22%, respectively, by year-1 follow-up, despite appreciable clinically beneficial impact of MTP[38]. Our data are more similar to those reported in the TRAMI registry[26] and the independent European Registry[28]. In fact, the group of 34 patients who underwent the MR correction by MTP system reported, on average, 1.8 hospitalizations/years/patient before intervention, which is higher than expected in an unselected group of congestive HF patients[11], but consistent with data from advanced HF management in a different centre from the 'Campania' regional health system[35]. Nevertheless, the cohort of patients from the validation center represents a specific sub-set of HF patients, with particularly elevated instability[16]. After MTP, the rate of re-hospitalization fell significantly to

Table 3. Global budget consumption in the cohort of HF patients with symptomatic MR, based on DRG billing system.

Medical management (DRG 127)		Treatment by MTP (DRG 104)	
Deficit simulated for an average case of DRG 127 with 9 days of hospital stay at a cost of €500 per day	€1,448.00	Deficit simulated for an average case of DRG 104 undergoing MitraClip, with 9 days of hospital study at a cost of €500 per day	€850.00
Hospitalizations expected per patient in 2 years	3.6	Hospitalizations expected in 2 years	10% of the cohort
Deficit times number of hospitalizations in 2 years for each case	€5,212.80	Deficit times number of hospitalizations in 2 years for each case	€2,890.00
Deficit estimated for the cohort of 34 HF patients	€177,235.20	Additional costs estimated for the cohort of 34 HF patients due to hospitalizations	€34,290.00
DRG-related billing costs for the 34 patients in 2 years considering the hospitalization rate	€373,564.80	DRG-related billing costs for the 34 patients in 2 years	€833,000.00
Global costs (DRG+deficit) in 2 years	€550,800.00	Global costs (DRG+deficit) in 2 years	€867,290.00
Global costs (DRG+deficit) in 8 years	€2,203,200.00	Global costs (DRG+deficit) in 8 years	€992,890.00

The table reports data generated in two scenarios: the column under DRG 127 represents the budget consumption for the medical approach (conservative), based on an average case and the number of hospitalizations per case-year as measured in the study; the column under DRG 104 represents the budget consumption simulated for an average case of a patient undergoing MR treatment by MTP, which is the Mitraclip trans-catheter procedure. The theoretical model takes into account a mean life expectancy of 8 years based on the Seattle Heart Failure Model (see text for details), and 10% of unplanned hospitalizations/year in the interventional scenario. Of note, the Seattle Heart Failure Model estimates mean life expectancy independently of MR. DRG-related reimbursement and cost per day of hospitalization impact the estimates, which may vary in different regions of Italy, and furthermore in different Countries.

10%/year. Assuming a mean life expectancy of 8 years for the 34 patients comprised in the MTP cohort, as estimated by the Seattle Heart Failure Model[34] which is MR independent, the burden of conservative approach may overtake the costs determined by percutaneous treatment, even assuming a re-hospitalization rate of 10%/year (Table 3), as also suggested by year-4 follow-up analyses in the EVEREST II trial[36].

Global costs of medically-treated patients with advanced HF and MR may have been under-estimated in our study, since we considered only hospitalizations-derived costs. In the ASCEND-HF trial, 30-day cumulative cost of treatment of acute HF patients reached €12,000 per patient with a reported duration of hospitalization of 8.5 days, on average[3]; in the ASCEND-HF study, at 6-month follow-up, cumulative cost for HF management per patient was comprised between €25,000–€30,000. In the IN-HF network, duration of hospitalizations was of 10 days on average, which is likely to generate deficit according to Table 1. It has been suggested that outpatients may absorb between €855–€1442 per patient-year just by prescriptions[4]. Hence, the temporal horizon at which global costs of conservative approach may overtake those by MTP could be set at year-4 follow-up, as predicted according to Table 3. Most importantly, in the cohort from the validation center, QoL index improved significantly with MTP, as expected[22,29,30], with a mean incremental QoL of 0.38, or +95% from baseline. Thus, in a hypothetical incremental cost-utility evaluation, based on data reported in the right column of Table 3, for the MTP program remains cost-effective, as suggested based on data from randomized-controlled study[29,30]. Interestingly enough, MTP significantly improved QoL and functional capacity in non-responders to cardiac re-synchronization therapy[21], demonstrating that in HF patients targeting pathophysiological mechanisms is clinically important.

In a cohort of HF outpatients, it was reported that MR predicts mortality but not recurrent hospitalizations[9]. Significant MR predicted untoward outcome in chronic HF in a large Italian cohort[11]. Profiling best candidates to percutaneous treatment of MR by MTP is, therefore, needed in order to reach sustainable health resource consumption. Experience from the trans-catheter aortic valve replacement demonstrates that treatment costs increase with increasing patients' global cardiovascular risk profile[39], reducing the potential benefit of high cost treatment strategies. In fact, as reported by Neuss *et al.*[40], in HF patients treated with MTP, the rate of fatal events in the short-term may be very high for very critically ill patients, i.e., those with NYHA stage 4, significant right ventricular dysfunction, advanced renal insufficiency, older age, and very elevated natriuretic peptides. Severe renal failure may be an important determinant of outcome in HF patients[41]. Actually, those clinical characteristics contribute to determine both elevated cardiac surgery risk and potentially lower-than-expected benefit in terms of clinical stabilizations, recurrent hospitalization, and/or fatal events prevention with MTP. Hence, candidates to MTP cannot be simply patients at an excessive risk for cardiac surgery, although a warning has been raised on the tendency to extent MTP indications toward more healthy patients

because of an excessive risk of cardiac surgery post-MTP[23]. Notably, post-MTP cardiac surgery is relatively infrequent, and it is well established that MTP cannot be considered an alternative to cardiac surgery, but a specific treatment for a specific sub-set of HF patients.

Conclusions

The costing model considering the DRG billing system, hospitalization length, and costs per day of hospitalization, and accounting for actual device price, the MTP program might be cost-effective in selected patients compared to conservative management, granted that clinical benefits from MR treatment persist for years. On the other hand, untreated MR in advanced systolic HF may be associated with elevated costs and deficits for the public health system, in large part due to recurrent and long hospitalizations.

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