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Efficiency of organ procurement and transplantation programs

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Abstract The number of donations per million population (pmp) per year and the number of transplants pmp/year enables one to compare donation or transplant programs made in different years in the same area or made the same year in different areas. These pmp indexes may be integrated with an evaluation system by which each organ is evaluated separately in terms of the efficiency of its procurement and transplant systems using the procurement index (percentage in terms of number of organs utilized/number of organs procurable from donors utilized in a single area during 1 year) and the transplant index (percentage in terms of number of transplants performed/number of organs harvested in a single area during 1 year). We have called them Caldes I (procurement) and Caldes II (transplant) indexes. The harvest index evaluates the efficiency of utilization of organs retrieved from suitable donors. It usually ranges between 80–90% for the kidney, 70–95% for the liver, 40–50% for the heart, and 5–15% for the lungs. The transplant index evaluates for

each organ the transplant team capacity to use available organs which can be harvested locally or in different areas. It usually ranges between 60–120%. Index determination did not require information different from the standard data available. Both the harvest and transplant indexes could be used to compare the efficiency of donation and transplant programs and policies in the same area during different years or at the same time in different areas. They can be critical in evaluating: (a) marginal donor utilization, (b) marginal organ utilization, and (c) dishomogeneity of organ retrieval and organ transplantation in different regions belonging to the same area. They also enable to evaluate if organs considered not available in a single area are offered to other areas or are not retrieved at all from available donors.

Key words Organ procurement · Organ transplantation · Procurement programme efficiency · Transplant Programme efficiency · Evaluation indexes

Introduction

Current assessment of organ procurement and transplantation in a region, nation, or group of nations are based on the number of donors utilized and transplantations effected per million population (pmp) during a pe-

riod of time (conventionally 1 year) [1, 2, 8, 15]. The number of donations pmp/year and the number of transplants pmp/year enable one to compare donation or transplant programs made in different years in the same area or made the same year in different areas. Table 1, which shows the number of cadaver donations

Table 1 Number of cadaver donations in absolute number and per million population (*pmp*) in European countries during 1998

Country	Cadaveric donors	
	Number	Pmp
Austria	166	20.8
Belgium	194	19.4
Bulgaria	-	-
Croatia	22	4.7
Czech. Rep.	198	19.2
Denmark	58	11.0
Estonia	20	13.3
Finland	102	19.8
France	993	16.8
Germany	1073	13.4
Greece	57	5.7
Hungary	126	12.2
Italy	710	12.3
Latvia	24	10.4
Lithuania	13	3.6
Luxemburg	7	17.5
Norway	69	15.6
Poland	289	7.5
Portugal	166	16.7
Slovak Rep.	83	15.5
Slovenia	27	13.5
Spain	1250	31.5
Sweden	129	14.6
Switzerland	108	15.4
The Netherland	196	13.1
UK + Ireland	846	13.5

pmp in European countries during 1998, is a clear example of this type of analysis [3]; it gives a quantitative photograph of procurement and transplant programs for each organ, without evaluating the potential results on the basis of the number of donors utilized.

We suggest integrating the worldwide *pmp* indexes used with an innovative evaluation system by which each organ is evaluated separately in terms of the efficiency of its procurement and transplant systems. The instruments we propose (Table 2) are the procurement index (percentage in terms of number of organs utilized/number of organs procurable from donors utilized in a single area during 1 year) and the transplant index (percentage in terms of number of transplants performed/number of organs harvested in a single area during 1 year) [7]. We have arbitrarily called them Caldes I (procurement) and Caldes II (transplant) indexes; Caldes is a picturesque village in the district of Trento, with a wonderful alpine landscape, where one of the au-

thors of this paper was born. Caldes indexes aim to integrate the *pmp* index by evaluating the percent efficiency of such programs in relation to the maximum potential activity

Materials and methods

The procurement index (Caldes I) evaluates for each organ the efficiency of utilizing organs retrieved from suitable donors. It is calculated by dividing the number of utilized organs by the maximum number of organs procurable from all utilized donors (real donors) and multiplying these results by one hundred. It usually ranges between 80–90% for the kidney, 70–95% for the liver, 40–50% for the heart, and 5–15% for the lungs; mostly it depends on the capacity of the local transplant center to use marginal donors and on the capacity of the reference center to allocate the locally available organs (especially the marginal donor organs) in other transplant centers.

The transplant index (Caldes II) evaluates for each organ the transplant team capacity to use available organs which can be harvested locally or in different areas. Organ by organ it is calculated by dividing the number of transplanted organs by the number of procured organs and multiplying these results by one hundred; it usually ranges between 60–120% and depends both on transplant organization ability to procure and transplant center ability to utilize as many organs as possible. If the numbers of organs procured is higher than those transplanted, the index is lower than 100%: the area makes over its surplus of transplantable organs. If the number of organs transplanted exceeds that of the organs procured, the index is above 100%: the area acquires organs from other areas.

We applied this method to the activity of the Italian Interregional Centers in 1998. As far as procurement and transplant activities are concerned Italy is divided into three main areas: NITp (North Italy Transplant program including north-east and middle-east regions with a population of 18.3 million), AIRT (Interregional Transplant Association including north-west and central regions with a population of 12.3 million), and OCST (South Center Transplant Organization including south-central and south regions with a population of 12.1 million). When this analysis was performed, three regions in the south of Italy with a population of 15 million were not included in any organization.

Results

Figure 1 details the Italian 1998 scene describing donations in *pmp* [17, 18]. Donor and organ procurement in AIRT and NITp are on the best European levels while OCST activity shows a noticeably lower performance. It shows in particular that donor procurement was 18.1 *pmp* in the NITp area, 19.0 *pmp* in AIRT area, and 6.9 in OCST area. The situation for organ transplantation is similar.

Table 2 Procurement index (Caldes I) and transplant index (Caldes II) definitions

Procurement index (Caldes I)	Transplant index (Caldes II)
$\frac{\text{Number of utilized organs}}{\text{Number of procurable organs}} \times 100$	$\frac{\text{Number of transplanted organs}}{\text{Number of utilized organs}} \times 100$

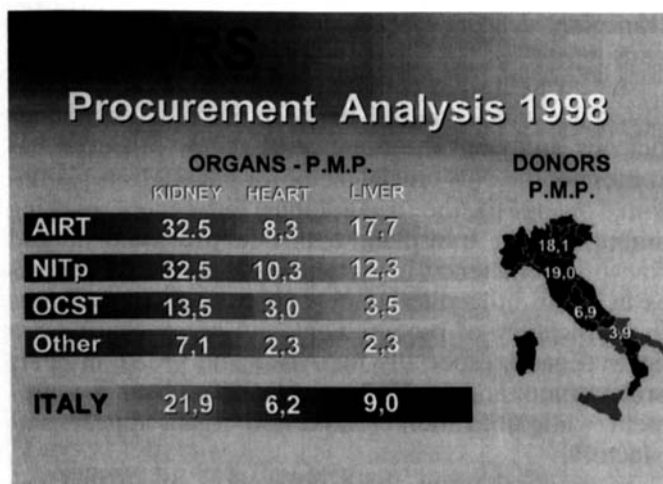


Fig. 1 Donor and organ procurement in Italy in 1998. Values expressed as donations per million populations (PMP). Analysis of transplant organization activity. AIRT Interregional Transplant Association, NITp North Italy Transplant program, OCST South Center Transplant

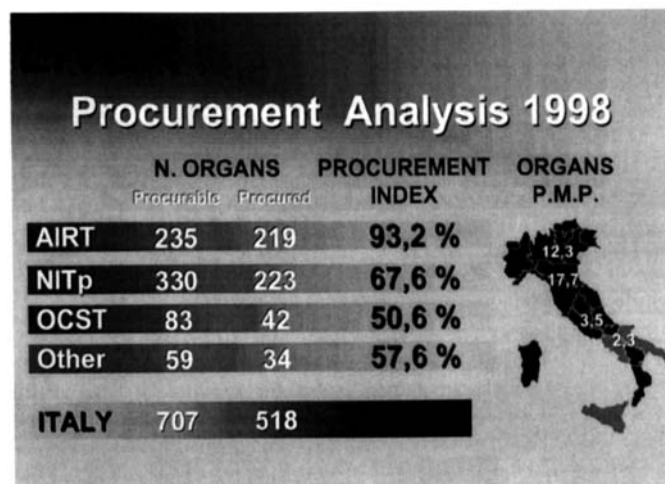


Fig. 3 Liver procurement index in Italy in 1998. Analysis of transplant organization activity

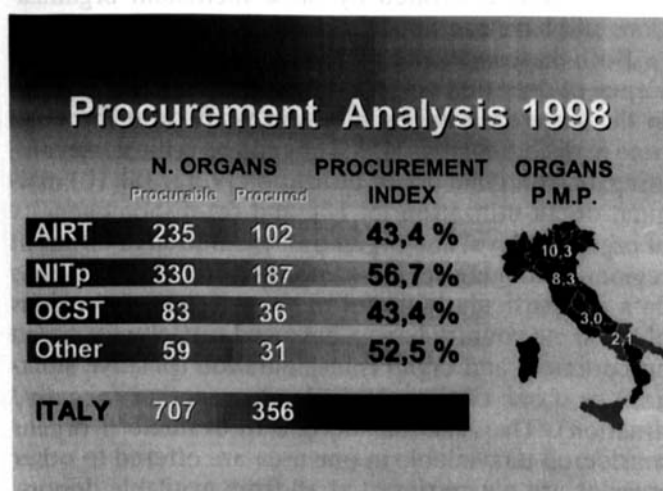


Fig. 2 Heart procurement index in Italy in 1998. Analysis of transplant organization activity

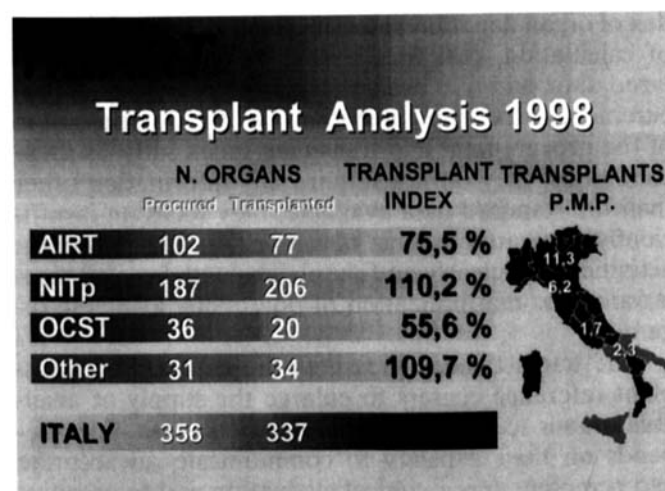


Fig. 4 Heart transplant index in Italy in 1998. Analysis of transplant organization activity

Figures 2–5 show an example of analysis based on the efficiency indexes we proposed applied to organ procurement and organ transplantation in Italy in 1998, focusing on the heart and liver transplant activity performed by the three interregional Italian transplant organizations.

Figure 2 reproduces the procurement index for the heart in 1998: it shows in particular that heart procurement is more efficient in the NITp area (56.7%) than in the AIRT (43.4%) or OCST areas (43.4%); on the contrary Fig. 3 underlines that liver procurement is noticeably more efficient in the AIRT (93.2%) than in the NITp (67.6%) or OCST areas (50.6%). Figures 4

and 5 reproduce the transplant index in Italy for the heart and liver in 1998. Again the differences between Italian organizations are remarkable: the heart transplant index is 75.5% in the AIRT and 55.6% in the OCST area, while it reaches 110.2% in the NITp area; the liver transplant index is 100% in the AIRT area, owing to full utilization of procured livers, 121.1% in the NITp area thanks to the split liver transplantation program and 114.3% in the OCST area probably because of some southern regions, not yet taking part in the OCST program, transferring the livers they procured to the OCST transplant center.

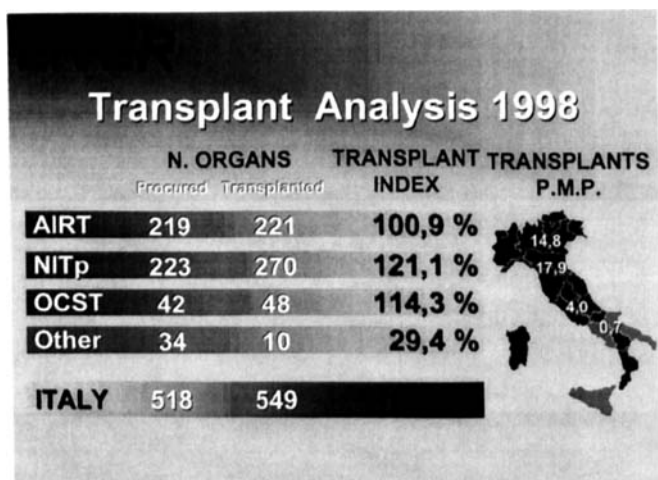


Fig.5 Liver transplant index in Italy in 1998. Analysis of transplant organization activity

Discussion

The most important requirements for an efficiency index of organ donation and transplantation are simplicity of calculation, real focalization of insufficiently analyzed data, and true evaluation of the efficiency of procurement and transplant systems [4, 10]. Determination of the procurement and transplant index satisfies these conditions: they do not require any information other than the standard data available, they focus on insufficiently evaluated aspects of harvesting and transplant activities, and clearly and simply evaluate for a particular area the real utilization of potentially available organs.

The harvest index measures the capacity of transplant reference centers to enlarge the supply of available organs to many transplant centers. This index depends on their capacity to communicate an accurate and complete donor clinical evaluation and to organize rapid transportation of surgical teams with harvested organs. The transplant index depends on the capacity of transplant organization to rapidly respond to organ offers and to accept and allocate organs in areas with

transplant centers specialized in utilizing marginal organs.

As far as Italy is concerned it is curious to note the difference which emerges between pmp analysis and efficiency analysis. The number of donor procured becomes not the only crucial factor for patient transplantation, owing to the remarkable differences existing among Italian transplant teams in procurement and transplant efficiency. In particular the marked differences in organ utilization among different areas indicates that efficiency of procurement and organ sharing are not sufficient, especially for AIRT and OCST in heart procurement and for NITp and OCST in liver procurement, while utilization of harvested organs appears satisfactory.

In practical terms these differences mean that patients waiting for a heart in the AIRT and OCST areas can count on a lower number of hearts which is lower than expected on the basis of utilized donors, and that patients waiting for a liver in the NIT and OCST areas have to make do with a liver number which is lower than expected on the basis of donor numbers. The ethical questions generated by these inefficient organizations still have to be evaluated.

Both these indexes could be used to compare the efficiency of donation and transplant program and policies in the same area during different years or at the same time in different areas [15]. They can be critical in evaluating: (a) marginal donor utilization [9, 11, 13], (b) marginal organ utilization [5, 12], and (c) dishomogeneity of organ retrieval and organ transplantation in different regions belonging to the same area [6, 14, 16]. These data are particularly useful to show if areas or regions of the same country have a balanced capacity for organ procurement and organ transplantation (positive situation) or if one of them prevails over another (negative situation). They also enable one to evaluate if organs considered unavailable in one area are offered to other areas or are not retrieved at all from available donors. The combined use of these parameters may, therefore, provide a real efficiency evaluation of procurement and transplant programs.

References

1. Council of Europe. Select Committee of Experts on the Organizational Aspect of Cooperation in Organ and Tissue Transplantation (1996) In: Mate-sanz R, Miranda B (eds) Meeting the organ shortage: current situation and strategies for improvement. Transplant newsletters, vol 1, N. 2. Aula Medica Ed., Madrid
2. Council of Europe. Select Committee of Experts on the Organizational Aspect of Cooperation in Organ and Tissue Transplantation (1998) International figures on organ donation and transplantation activities 1997. *Organs and Tissues* 1: 69-73
3. Council of Europe. Select Committee of Experts on the Organizational Aspect of Cooperation in Organ and Tissue Transplantation (1999) International figures on organ donation and transplantation activities 1998. *Organs and Tissues* 2: 73-78

4. Espinel E, Deolofeu R, Sabater R, Manyalich M, Domingo P, Rue M (1989) The capacity for organ generation of hospitals in Cataluna. *Transplant Proc* 21: 1419-1421
5. Evans RW (1995) Need for liver transplantation *lancet* 346: 1169
6. Evans RW, Orians CE (1992) The potential supply of organs donors. *JAMA* 267: 239-246
7. Ghirardini A, Nanni Costa A, Venturi S, Ridolfi L, Petrini F, Taddei S, Venturoli N, Monti M, Martinelli G (1999) Evaluation of the efficiency of organ procurement and transplantation programmes (1999). *Transplant Proc* (in press)
8. Matesanz R (1997) The Council of Europe and organ transplantation. *Transplant Proc* 29: 3205-3207
9. Matesanz R, Miranda B (1995) "Marginal quality" donor livers: not so marginal. *Clin Transplant* 9: 492
10. Matesanz R, Miranda B, Felipe C, Naya MT (1996) Continuous improvement in organ donation. The Spanish experience. *Transplantation* 7: 1119-1121
11. Miranda B, Segovia C, Sanchez M, Felipe C, Naya MT, Matesanz R (1995) Evolution of organ procurement and donor characteristics in Spain. *Transplant Proc* 27: 2384-2388
12. Miranda B, Felipe C, Fernandez-Lucas M, Naya MT, Matesanz R (1996) Organs retrieved and not used for transplantation. *Transplant Proc* 28: 177-179
13. Miranda B, Matesanz R, Fernandez Lucas M, Naya MT, Felipe C (1996) Organ donation in Spain: evolution of organ donor characteristics. *Transplant Proc* 28: 175-176
14. Miranda B, Matesanz R, Fernandez Lucas M, Felipe C, Naya MT (1996) Integrated ways to improve cadaveric organ donation. *Transplant Proc* 28: 96-97
15. Miranda B, Fernandez-Lucas M, Matesanz R (1997) The potential organ donor pool: international figures. *Transplant Proc* 29: 1604-1606
16. Nanni Costa A, Ridolfi L, Taddei S, et al (1999) Regional integration for widescale transplant coordination: the AIRT model. *Nephrol Dial Transplant* (in press)
17. Nanni-Costa A, Ridolfi L, Riganello I, Taddei S, Venturoli N, Persico L, Monti M (1999) Associazione Interregionale Trapianti AIRT: attivit  di donazione, prelievo e trapianto di organi; report 1998. Editrice Compositori Bologna
18. Quintieri F, Pugliese P (1999) Organ donation and transplantation in Italy, year 1998. *Organs and Tissues* 2: 91-93