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ARTICOLI ORIGINALI

Ecodialysis: first strategiest to limit damages and reduce costs



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Abstract

In the medical field, the attention to the environmental impact of industrial processes and products is still limited. In recent years there has been an increased sensitivity towards the environment; meanwhile, the economic burden of hazardous waste disposal is becoming evident.

Dialysis is a "big producer" of waste and it has been estimated that disposal costs can be up to 10-40% of the cost of disposables.

So there are several reasons of interest on "ecodialysis": the high amount of waste defined as "potentially hazardous", which requires a very expensive management and the recyclability potential of the non-contaminated waste, that has not yet been fully explored in dialysis.

This primary study has been performed in collaboration with the Politecnico di Torino. Its aim has been to define a schedule of activities by a few brainstorming sessions. This schedule is to be readily performed or it should be developed in detail to optimize, by reducing and recycling, the waste production during the dialysis session.

The discussion identified seven basic points for the eco-sustainability of haemodialysis to: [1] reduce packaging; [2] facilitate separation of materials, and [3] their discharge; [4] differentiate materials; **[5]** clearly highlight the potentially hazardous materials; [6] improve the recyclability of plastic products; [7] propose a path of recovery and reuse.

Although a full optimization requires a close cooperation with the manufacturers and is achievable only in the long term, the reduction of one pound of potentially contaminated materials could presently lead, on a national scale, to a saving of several million euros, which can be better employed in investments to improve our treatments.

Key words: brainstorming, ecodialysis, hazardous wastes, recycle

Introduction: will we end-up suffocated by the wastes?

In the medical field, the attention to the environmental impact of industrial processes and products has historically been very limited. The procedures for waste disposal are not con-

sidered of medical interest and related costs are not typically calculated among the expenses, and are usually collected in the "cauldron" of indirect costs of treatments.

This historical lack of interest may be now reconsidered: the precarious ecosystem in which we live is increasingly seen as a crucial factor in the pathogenesis of many diseases, and, consequently, as an element on which acting in terms of prevention. This highlights the urgent need to address a number of problems, such as toxic waste or non-recyclable substances [1] [2] [3]. Furthermore, the recent global economic crisis has emphasized the costs, direct and indirect, for diagnostic and therapeutic procedures, including dialysis treatment.

In this context, it may be surprising to find that the costs of waste disposal may be up to 10-40% of the cost of disposables [4] [5].

According to the World Health Organization (WHO), the sanitary waste (HCW - Health Care Waste) is defined as the total amount of waste from healthcare facilities, including “hazardous” waste, that is potentially infectious, and not contaminated waste. The hazardous waste includes sharps and non-sharps. In contrast, the non-hazardous waste include materials that have not come into direct contact with the patient, such as paper and plastic packaging, metals, glass or other waste similar to household ones. It is important to note that, if no waste separation is done, the entire bulk of medical waste should be regarded as potentially hazardous [6].

In Italy, the disposal of hazardous waste is regulated by the Decree of the President of the Republic of 15 July 2003, (254-Regulations governing the management of medical waste in accordance with Article 24 of the Law of 31 July 2002 n. 179 [7]), which states that hazardous and infectious waste must be disposed of by incineration, as such or after being sterilized (art. 7:09).

The composition of medical waste varies depending on the area, the type and extent of medical facilities, clinical specialty and available procedures [8]. Regardless of their amount, the hazards can be reduced with proper waste management and by appropriate segregation and recycling [4] [9] [10].

The recycling process is very complex and delicate, in which a few elements may be processed together and the presence of even small quantities of glues, inks or other materials (such as plastic labels) can impair the input in the recycling process [2] [11].

Dialysis and waste

There are various reasons for which the problem of waste is of extreme relevance in dialysis: the first relates to the dialysis itself, because it is a treatment in which the patient's blood is in contact with a series of semi-permeable membranes and passes through a series of plastic “ducts”; dialysis blood circuit is an obvious example of “hazardous”material. The fact that each dialysis session requires a wide and heterogeneous range of disposable materials, makes this treatment a prototype of high waste production in general, and of contaminated wastes in particular.

It has been calculated that each year about six hundred thousand tons of hazardous waste are produced by dialysis in the world. If in 2025 we will reach the forecasted five million patients on extracorporeal dialysis, versus the two million today, waste production will increase accordingly, with a frightening increase in management costs [12] [13] (full text) [14] [15].

If the cost is the main problem of "potentially hazardous" waste, the potential of recycling is the key issue with regard to the non-hazardous waste, which ideally should be managed

according to a program of limiting production, increasing reuse and recycling. However, presently the latter is possible only for a minority of products, either for structural problems, or as a reflection of a lack of attention to the combination of different materials, including the use of adhesives, glues and trace substances that impair recycling, together with a non-ergonomic design that doesn't take into account the "final" waste destination.

From water to land, the wake-up call for an eco-dialysis

Most of the published works highlighting the problems of waste disposal, water and energy needed for dialysis therapy, and possible interventions for increasing the eco-sustainability, are from Australian Authors.

Conserving water is a central issue; innovative solutions were envisaged, such as the use of the water "waste" of the osmosis to produce gardens in dialysis centers, with the aim of conserving resources, offer employment and provide rehabilitation to patients, while producing organic food [16] [17].

While we can smile from this Proudhonian vision in this era cynically far from Utopian impulses, the proposal reminds that the integration of dialysis into the life of patients should also be combined with the integration into our ecosystem [16] [17].

A series of very interesting studies on the preservation of water comes from another area of the thirsty world, the Maghreb, where alternatives to water disposal have a true connotation of preserving life and increasing dialysis avaibility [18] [19] [20] [21].

Although still limited, the experiences of "ecodialysis" are on the rise, thanks also to a greater awareness of the industry, that albeit slowly begins to take its first steps towards the rationalization of the production and waste processes [22] (full text).

These considerations are the basis of several creative educational projects of the network "Green Nephrology", even involving the creation of toys, including a polar bear made with plastic packaging for dialysis, as a fun and interactive way to help children on dialysis to learn about environmental issues and to understand what they can do to face them [23].

A collaborative Italian project

In a context in which care for the environment and focus on innovation meet, we started a collaboration between a new small hemodialysis and home dialysis Center and the team of Systemic Design, Department of Architecture and Design at the Politecnico di Torino, which has developed a methodology for the analysis of the life cycle of industrial products in a sustainable environment [24].

The challenge of a consumer society that produces artifacts with a short life-span is to evolve from a manufacturing model to a linear production model. The latter is also called "systemic", and is characterised by the fact that the waste of a production process become resources for a new production process, thus switching from a "cradle to grave" life cycle, to a "cradle to cradle" one [25] [26].

In this context, the aim of the present report was to highlight a series of issues at the basis for detailed analysis and a redesign, starting from the packaging materials of dialysis, to waste management. This was done through a series of interdisciplinary brainstorming sessions, which involved nephrologists, nurses and experts in systemic design.

Methods

The brainstorming sessions were performed over one year of activity. The first three sessions combined the opinions of a Nephrologist, a nephrologist in training and a medical student with a researcher at the Politecnico di Torino (architecture and design), and a PhD student in Management, Production and Design.

Further, the identified problems were discussed with the nursing staff in two occasions, and the nursing staff finally conducted a series of dedicated focus groups.

On each occasion a written diary of the session was kept and the notes were revised by participants before the next session.

The topics identified in the brainstorming sessions were then taken into account in the focus groups. These were the critical issues of materials disposable packaging, the way to manage "potentially hazardous" waste and the educational strategies to be put in place to implement an optimal nursing management of dialysis waste.

Results: Seven critical points

The discussions identified seven major points in order to improve the eco-sustainability of hemodialysis:

1. To resize packaging. From the analysis emerges as most of the packaging are oversized with respect to the content, which occupies in many cases about 50% of the packaging and rarely exceeds 75%. This results in a considerable waste of space during storage (with impact on transport costs) and unnecessary volumes of paper and cardboard to be disposed. This chapter also includes preformed plastic templates, which are bulky and structurally unnecessary, designed to "drive" and facilitate the assembly of certain dialysis machines.

2 To facilitate the separation of materials. Many containers-packaging are made from different components. In most cases they do not bear information about the materials. In some cases the components are intuitively separated (eg. papers and plastic in packaging of sterile products), however, due to the lack of communication paper and plastic are often discharged together.

3. To facilitate the emptying of residual fluids. After use, many materials (such as bags or bicarbonate cartridge) still contain significant quantities of fluids, according to the type and duration of treatment. Many machines now have an automated method for emptying the dialysis filter. Other fluids residues are discharged together, increasing the waste weight, with important economic consequences, in particular if the waste is disposed along with hazardous materials.

4. To differentiate the materials and to use, where possible, materials which can be recycled together. The lack of differentiation of the materials is not only a problem in packaging, but also in many disposables, both hazardous (the filter) and non hazardous (the dialysis bags).

5. To clearly highlight the hazardous materials versus those that are not normally contaminated by biological fluids (such as the acid solution).

6. To improve the recyclability of plastic products. Few plastic materials belong to "families" suitable for a joint recycling. The dialysis material is characterized by a substantial use of laminated plastics and by a mixture of heterogeneous polymers, with different recyclability (eg PVC - Polyvinyl chloride, PE - Polyethylene, PS - Polystyrene). Furthermore, they are difficult to separate, and labelling, glues and joints hinder the recycling process.

7. To propose paths for recovery of packaging, such as cardboard boxes, or pre-assembled templates. The recovery could be extended also to not contaminated disposables, such as the bicarbonate cartridges, which could be restored and reused.

Working conclusions

The watchwords of the lifecycle analysis are reduce-recycle-reuse.

The first point is to reduce the amount of waste, feasible at different levels, even with "minimal efforts", such as, for example, reducing wraps of dialysis disposables, or avoiding the plastic templates, that are bulky and structurally unnecessary.

Recycle and reuse have never been passwords with regard to dialysis materials; they could be easily increased with greater attention at identifying dedicated paths, with the collaboration between companies that produce materials and companies that dispose waste. Such a long-term program could be strongly promoted the nephrologists and dialysis nurses, although not unworkable, it depends on the awareness of the dialysis Companies, of the hospitals and, at least in many parts of Italy, of the Community (it is difficult to imagine that a careful waste collection is done in the hospital, if no one does it at home).

Presently, however, an immediate feasible goal could be the correct sorting of hazardous and non hazardous materials, performed only in part of our dialysis centers. Such a simple and rapid procedure can halve the cost of waste disposal, which is almost entirely due to the amount of hazardous waste (costs are highly variable in Italy, with an average of 2 Euro per kg, from 1 up to more than 5 Euro per kg).

Although on an individual basis savings may seem minor, on a national Italian scale the savings of 50 cents per dialysis (100 to 250 grams of hazardous waste) would lead to saving about 5 million Euro per year, that, translated into more fruitful research grants would lead, for example, to enrol a task force of about 150 researchers, devoted to the most thoroughly analysis of all ecological and economic aspects of dialysis.

References

[1] Connor A, Mortimer F The green nephrology survey of sustainability in renal units in England, Scotland and Wales. Journal of renal care 2010 Sep;36(3):153-60

[2] James R Incineration: why this may be the most environmentally sound method of renal healthcare waste disposal. Journal of renal care 2010 Sep;36(3):161-9

[3] Lim AE, Perkins A, Agar JW et al. The carbon footprint of an Australian satellite haemodialysis unit. Australian health review : a publication of the Australian Hospital Association 2013 Jun;37(3):369-74

[4] Lee BK, Ellenbecker MJ, Moure-Ersaso R et al. Alternatives for treatment and disposal cost reduction of regulated medical wastes. Waste management (New York, N.Y.) 2004;24(2):143-51

[5] http://eur-lex.europa.eu/ (ultimo accesso a luglio 2014)

[6] www.who.int (ultimo accesso a luglio 2014)

[7] www.normattiva.it (ultimo accesso a luglio 2014)

[8] Cheng YW, Li KC, Sung FC et al. Medical waste generation in selected clinical facilities in Taiwan. Waste management (New York, N.Y.) 2010 Aug-Sep;30(8-9):1690-5

[9] Almuneef M, Memish ZA Effective medical waste management: it can be done. American journal of infection control 2003 May;31(3):188-92

[10] Sabour MR, Mohamedifard A, Kamalan H et al. A mathematical model to predict the composition and generation of hospital wastes in Iran. Waste management (New York, N.Y.) 2007;27(4):584-7

[11] Miranda ML, Hale B. Waste not, want not: the private and social costs of waste to energy production. Energy policy. 1997 May;26(6):587-600

[12] Agar JW Personal viewpoint: hemodialysis--water, power, and waste disposal: rethinking our environmental responsibilities. Hemodialysis international. International Symposium on Home Hemodialysis 2012 Jan;16(1):6-10

[13] Tarrass F, Benjelloun M, Benjelloun O et al. Water conservation: an emerging but vital issue in hemodialysis therapy. Blood purification 2010;30(3):181-5 (full text)

[14] Ferraresi M, Pereno A, Castelliccia N, et al. Dialisi ecologica: utopia o realtà? Revisione sistematica della letteratura. Atti congressuali del 54° Congresso Nazionale SIN - Firenze 25-28 settembre 2013

[15] Ferraresi M, Pereno A, Nazha M, Barbero S, Piccoli GB. Ecodialysis: is it possible to design an eco friendly system? Atti congressuali del 51° Congresso Europeo ERA-EDTA – Amsterdam 31 maggio-3 giugno 2014 (vincitore di Travel Grant)

[16] Agar JW Conserving water in and applying solar power to haemodialysis: 'green dialysis' through wiser resource utilization. Nephrology (Carlton, Vic.) 2010 Jun;15(4):448-53

[17] Agar JW, Simmonds RE, Knight R et al. Using water wisely: New, affordable, and essential water conservation practices for facility and home hemodialysis. Hemodialysis international. International Symposium on Home Hemodialysis 2009 Jan;13(1):32-7

[18] Shah K Dialysis unit's high quality supply. Health estate 2013 Sep;67(8):57-8

[19] Fournier C The future of water for dialysis. Nephrology news & issues 2010 May;24(6):48, 50-1

[20] Twardowski ZJ Dialyzer reuse--part II: advantages and disadvantages. Seminars in dialysis 2006 May-Jun;19(3):217-26

[21] Dousson C, Ripault B, Leblanc MA et al. [Prevalence of latex allergy among personnel at a hospital]. Allergie et immunologie 1994 Dec;26(10):367-73

[22] Connor A, Mortimer F, Tomson C et al. Clinical transformation: the key to green nephrology. Nephron. Clinical practice 2010;116(3):c200-5; discussion c206 (full text)

[23] www.sustainablehealthcare.org.uk/green-nephrology/news/2010/10/can-you-bear-waste ultimo accesso a luglio 2014

[24] Barbero S, Tamborrini P. Observatory of Eco-Pack: Research and Teaching Exchange field. In E M Formia (Ed.) Innovation in design education. Theory, research and processes to and from a Latin perspective. (pp. 113). Turin, Italy: Allemandi. 2012

[25] Bistagnino L. Systemic design: designing the productive and environmental sustainability. Bra, Italy: Slow Food 2011.

[26] McDonough W. Cradle to cradle: remarking the way we make things. New York, USA: North Point Press 2002