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Kidney Allocation in Eurotransplant

*A Systematic Account of the Wujciak-Opelz Algorithm**

Abstract: In the Eurotransplant region transplantable kidneys from cadaveric donors are allocated according to the Wujciak-Opelz algorithm. This paper shows that the algorithm as it stands fulfils certain normative standards of a more formal nature while violating others. In view of these insights, it is explored how the algorithm could perhaps be improved. Even if issues of substantial rather than formal adequacy need to be addressed separately, analyses as presented in this paper can prepare the ground for a discussion of substantive normative issues. In any event, axiomatic accounts can tell us something about what we are in fact doing when using a procedure like the Wujciak-Opelz algorithm.

1. Introduction and Overview

The Wujciak-Opelz algorithm provides a criterion for allocating kidneys from cadaveric donors to individual recipients (see the original description in Wujciak/Opelz 1993a; Wujciak/Opelz 1993b). The application of the algorithm can even out interindividual differences of waiting times with only minor reductions in the quality of HLA-matching (which is basically used as a predictor of the survival prospects of the graft). Simulation studies that demonstrated this provided one, if not the decisive argument in favor of introducing the algorithm as an allocation criterion in the Eurotransplant region in 1996. Since then the algorithm, or variants of it, have been used for allocating kidneys.

In view of the latent conflict between those who prefer waiting time as an allocation criterion and those who defend organ allocation according to the quality of tissue matching it is clearly advantageous that the Wujciak-Opelz algorithm gives due weight to both waiting time and histo-compatibility. It is also advantageous that, after a patient is admitted to the waiting list, hardly any discretionary scope is left to doctors at transplant centers. Relying on the algorithm reduces the burden of potentially tragic choices resting on doctors' shoulders and at the same time enhances the patients' trust in the objectivity and impartiality of allocation decisions.

The Wujciak-Opelz algorithm is clearly an improvement over previous proce-

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dures. But this does not exempt the algorithm from critical evaluation. When specifying the algorithm, crucial decisions must be made on the 'constitutional' level of choosing the rules (see on the normative relevance of the distinction between 'choices of rules' and 'within rule choices' Brennan/Buchanan 1985). It must be justified on the level of rule choice why certain value dimensions are included and others not. Moreover, since several value dimensions are involved, a general method of weighing the various goods must be found and defended.

To begin with, we shall present—in an easy-to-understand form for non-specialists—certain axiomatic characterizations of central aspects of allocation algorithms in general and shall apply them preliminarily to the Wujciak-Opelz algorithm in particular. More specifically, we shall illustrate, first, using the ethically neutral example of the decathlon point table, what weighing goods is all about (2.). Then the very simple point scale structure of the Wujciak-Opelz algorithm is introduced (3.) and axiomatically discussed (4.). After exploring arguments for and against potential modifications of the Wujciak-Opelz algorithm (5.), some broader-based final remarks conclude the paper (6.).

2. Aggregation: The Example of the Decathlon

The decathlon is of interest not only to sportsmen. It is also a worthy object for other theorists (see in particular MacKay 1980) who intend to understand some aspects of the notorious problem of 'weighing goods' (see Broome 1991). Theorists of medical ethics who are always confronting potentially dramatic, substantial ethical issues should make use of the decathlon example exactly because it is more or less ethically neutral. Looking at it, they can sharpen their intuitions about the purely formal aspects of weighing goods by point scales like in the Wujciak-Opelz algorithm without mixing these issues up with substantial ones. Distancing oneself somewhat from the hard choices involved is clearly an advantage if a considered opinion is needed in a morally and practically contested area such as organ allocation. So let us briefly turn to the decathlon example.

In a decathlon competition, we are seeking an overall winner on the basis of performance in ten contests. Obviously, if an individual A finishes better than an individual B in all ten contests, we should insist that B should not win. B is dominated by A along all relevant dimensions of evaluation. However, if A is comparatively better than B in at least one contest while B is better than A in at least one contest, it is no longer true that one competitor dominates the other along all dimensions. If we nevertheless intend to say that one of the two competitors is 'the (sole) winner', we must be willing to decide, at least implicitly, on the relative merits of being superior along one and inferior along another dimension of value.

Looking more closely at the assignment of the point values along the different scales of measurement in a decathlon, several instructive observations can be made: First, in none of the contests there is a problem of measuring performance. Stop watches measure time, measuring rods height or length of jumps etc. Second, by aggregating the point values over several contests to one measure of overall performance, it is implicitly determined what the 'exchange' rate between, say, centimeters in the pole jump and seconds in the one hundred meter dash is. Third, the assignment of points to several measures of performance related to the separate contests is to a certain extent arbitrary, but not completely. Not only should better performances always receive higher point values. There are other elementary constraints that can be used in calibrating the scales. For example, world record performances in each discipline have some normative force. They may serve as 'focal points' of calibration processes. (One might even wish to treat all world record performances across the different disciplines equally by assigning the same point value to each.)

In any event, the standard argument of many scientifically minded theorists, in particular many economists, that the necessity of making *some* value judgment renders any process of deliberation completely arbitrary must be seen with great caution. In the decathlon example, a traditional theorist would presumably hasten to point out that the scales for evaluating decathlon performances have been adjusted several times in the past. Such changes, our skeptical theorist might claim, show how arbitrary the process of fixing such a scale is. But the presence of such changes may also be looked upon as indicating quite the opposite. For, if the fixing of the scale were purely conventional and arbitrary, why then bother and incur the transition costs? Why not stick to what we have, instead? Why not behave as the British do, by driving on the left rather than the right side of the street?

Nobody would claim that the right side of the street is the wrong side for any reason other than convenience or the size of the network adhering to the same convention. But in the decathlon example experts would actually claim that due to new developments in specific disciplines it became 'necessary' to change the functions that are mapping measures of physical performance into point values. Otherwise the relative weight of one or some discipline would seem to have become 'too high' or 'too low'. Such diagnoses depend, of course, on value judgments and are value judgments themselves. Nevertheless, they are not arbitrary—at least not completely so. There are some more fundamental values involved that allow for calibrating the scales in a quite controlled way. For instance, in case of the decathlon, the overall aim is to put a premium on being a 'true' generalist rather than a specialist, and this can serve as guidance in forming considered opinions in the ongoing search for a reflective equilibrium about the decathlon point tables (on reflective equilibrium, see Rawls 1951; Rawls 1971; Hoerster 1977; Daniels 1979; Hahn 1996). Scales and their relative weights should be fixed such that the specialist cannot outperform the generalist by some extraordinary result overshadowing all others.

In cases like organ transplantation, we may want to go beyond mere intuitions and plausibility considerations, wondering whether there are some 'formal' theoretical methods to assess the quality of weighing procedures in general. There are indeed some such methods whose application to organ allocation, in particular to the Wujciak-Opelz algorithm, we shall informally outline in the fourth, central section of this paper. But before turning to this task, let us first, for the sake of specificity, briefly introduce the simple point scale of the Wujciak-Opelz algorithm.

3. The Basic Structure of the Wujciak-Opelz Algorithm

By way of a preliminary remark, we should like to warn the reader that the version of the algorithm presented in this section is not the most recent one. It is just one of several scales that have been used under frequent adjustment of weights in the course of time. It does not make sense to look for the most recent scale since, when this is printed, there is bound to be another one in its place. As this is being written, for instance, regional transplant rates have been substituted by a dimension measuring distance. Moreover, children who used to get priority before the scale was applied, are now granted additional points on the scale. This will drive the percentage of organs that are allocated according to point values rather than according to some exception or other somewhere beyond the rather meager 50% of organs or so that are presently allocated in this way. Suffice it to note that the algorithm is in principle like the one presented here and all conflicts of interest, and only those, will show up by using our example of a scale.

According to the Wujciak-Opelz algorithm, organ allocation is based on ranking points (see again Wujciak/Opelz 1993a; Wujciak/Opelz 1993b). For any kidney, K, becoming available, the individual with the highest ranking point number will be chosen (unless high urgency patients—a relatively rare case in kidney transplants—special groups like children, or so-called 'full house' tissue matches—where all six antigen tests of HLA compatibility are met—take precedence). The point scale aggregates the values of five subscales. The subscales in turn assign point values to five aspects of the allocation problem deemed relevant by Eurotransplant.

For every individual i and every kidney K we have

$P_1^i(K)$ HLA compatibility (maximum of 4x100 points)
$P_2^i(K)$ 1-probability for better HLA (maximum of 1x100 points)
$P_3^i(K)$ waiting time on waiting list (maximum of 2x100 points)
$P_4^i(K)$ regional donation rate (maximum of 3x100 points)
$P_5^i(K)$ national exchange balance (maximum of 2x100 points)

The allocation rule is that, in comparing two potential recipients i and j from the waiting list for any kidney K becoming available, i should take precedence over j with respect to K iff

$$\sum_{v=1}^{5} P_v^i(K) \geq \sum_{v=1}^{5} P_v^j(K).$$

Applying such a point scale and criterion does not allow for much discretionary power. This high degree of interpersonal validity, however, does not amount to ruling out arbitrariness in setting up the scale. If we intend to control for the latter, we should strive to make explicit the fundamental values underlying it. As far as the more formal side of the matter is concerned, controlling for arbitrariness can be accomplished best by axiomatic characterizations of certain essential properties of aggregation procedures like the Wujciak-Opelz algorithm. For fulfilling certain axioms amounts to nonarbitrariness in the sense of living up to certain formal standards for 'good' aggregation procedures.

4. Axiomatic Analysis of the Wujciak-Opelz Algorithm

It may be, and usually is the case that those who defend the application of the Wujciak-Opelz algorithm as a criterion for organ allocation are totally unaware of the possibility of its axiomatic characterization. But if they are rational actors who are willing to reflect on, and possibly defend, the value judgments that underlie their practices, they should take an interest in axioms characterizing formal aspects of the Wujciak-Opelz algorithm. The axioms make merely explicit the values they are bound to endorse implicitly when applying the algorithm. But before turning to the axioms themselves in detail (4.3), let us define more precisely what the problem is (4.1) and what a solution to such a problem would look like (4.2).

4.1 Assignment of Kidneys as an Allocation Problem

In general, an *allocation problem* arises whenever a bundle of resources, rights, burdens or costs is temporarily held in common by a group of individuals and must be allotted to them individually. An *allocation* or *distribution* is an "assignment of ... objects to specific individuals" (Young 1994, 7, to which the subsequent discussion in this section refers throughout). More specifically, a *discrete zero-one* distributive problem as understood here is characterized by a group of claimants and a number of indivisible units of some good to be assigned to members of the group of claimants such that each member receives one unit at most.

Mathematically speaking, a *solution* of an allocation problem is a mapping from the set of claimants into the set of units. The solution is determined by an *allocation rule* which assigns a mapping or *allocation* to every allocation problem within its range of application. In case of a discrete zero-one distributive problem, the allocation rule specifies for each problem a zero-one allocation such that either 'one' or 'zero' units are assigned to each claimant.

The transplanting of kidneys within the Eurotransplant region quite obviously raises a discrete zero-one distributive problem. At any time all those who are on the waiting list form the relevant group of claimants. Any kidney that becomes available for transplantation is an indivisible good. Each kidney is to be allocated such that at any given time any patient on the waiting list gains access to one transplant at most (retransplanting is not excluded because a patient whose transplant fails is to be treated as a new patient entering the waiting list). Finally, the Wujciak-Opelz algorithm is an allocation rule which defines a solution—a zero-one allocation—to all kidney allocation problems likely to emerge in the Eurotransplant region.

4.2 Priority of Claimants

Which characteristics matter in determining the entitlement to the good to be allocated is in itself subject to basic value judgments. But once the relevant dimensions are fixed, a claimant is described by her characteristics. A complete list of characteristics that describe an individual claimant along all dimensions deemed relevant forms a ***type***. More formally, each claimant $I_i, i = 1, 2, ..., n$, is mapped to her corresponding type according to $f: I_i \rightarrow t_i$. Individuals I_i may, but need not differ in their types $f(I_i)$.

A ***standard of comparison*** is simply a list of all types ordered according to priority from the highest to the lowest. The presence of ties is not excluded. The standard orders ***all possible*** descriptions of potential claimants or the whole 'universe of types'. Therefore the standard of comparison implicitly orders every specific set of types in a ***priority list*** beforehand.

We refer to allocation procedures that rely on priority lists as '***priority methods***'. Given any priority list, a priority method allocates m units of the indivisible good to the m claimants with highest priority.

The fact that kidneys differ from each other and must be allocated very swiftly suggests that the allocation problem—at least initially—be framed such that $m = 1$. With each available kidney a new discrete zero–one distributive problem emerges. Thus, we consider the allocation problem for every kidney separately as a discrete zero-one distributive problem with one indivisible unit. Once a kidney becomes available, the standard of comparison for that kidney can be formed by ordering all conceivable types in terms of the specific properties of the available kidney. A priority rule for kidney allocation not only ranks all claimants according to type. Granting access to the highest-ranked individual also fixes the solution (the assignment mapping) of the allocation problem. (Since kidneys come in pairs, we could, of course, also consider allocation problems in relation to such pairs. However, for simplicity sake, let us continue with the specification of a new problem for each available kidney.)

4.3 The Wujciak-Opelz Algorithm as a Priority Rule

Young (see again 1994, in part. ch. 2) formulates some axioms that can be used to characterize allocation rules in general, and priority rules in particular. For each kidney K the allocation problem $((I_1, I_2 \cdots, I_n); K)$ must be transformed into a problem of re-ordering a list of types $((t_1, t_2 \cdots, t_n); K)$ such that a priority list for the specific kidney K emerges.

Once a kidney allocation problem is described in terms of types the application of Young's analysis to the Wujciak-Opelz algorithm is straightforward. Before we present Young's three basic axioms and apply them along with some of their implications to organ allocation, let us start with a more substantive background assumption.

4.3.1 Substantive Individualism

Within the context of Western medical traditions 'individualism' is very strongly entrenched. We capture this explicitly by the

Assumption of *Substantive Individualism*

An allocation rule is substantially individualist if its solutions (allocation functions) determine allocations exclusively as a function of data about the individual claimants and the objects to be distributed.

For illustration consider again the decathlon example. Here, a violation of the background assumption would not rule out the following: There are athletes A_1 and B_1 in decathlon d_1 and athletes A_2 and B_2 in decathlon d_2. A_1 and A_2 have identical results in all ten contests and B_1 and B_2 achieve identical results in all the ten contests, that is $A_1 \sim A_2$ and $B_1 \sim B_2$. Since $A_1 \sim A_2$ and $B_1 \sim B_2$, we would naturally expect: points$(A_1) \geq$ points$(B_1) \Leftrightarrow$ points$(A_2) \geq$ points(B_2). But, in d_1, say, competitor A_1 beats B_1 while in d_2, athlete B_2 beats A_2. In such a case, the relative ranking of competitors could not depend exclusively on their individual results since the performances are identical, but the ranking is different.

This result is impossible in the decathlon scheme applied here since its performance measure is a function of individual performances. But let us assume for the sake of argument that an extra dimension is introduced in which each athlete receives points in proportion to the number of decathlon athletes in his national track and field association. Then the effect described before could emerge in the following way: A_1 and B_2 come from a country with many athletes, B_1 and A_2 from one with few. Due to this discriminating factor A_1 can beat B_1 in d_1 and B_2 can beat A_2 even though $A_1 \sim A_2$ and $B_1 \sim B_2$ along the *other* dimensions.

It is possible to include the 'number of decathlon athletes in the track and field association in the country of the competitor's origin' as an extra dimension into the set of personal characteristics of each athlete. Collective properties can be *ascribed* to individuals *as if* they were individual ones. However, in the decathlon example in which point scales are introduced for the sole purpose of comparing *individual* performances across decathlons nobody would accept this violation of substantive individualism.

If a violation of the substantial—rather than the purely formal—requirement that the allocation be a function of individual characteristics seems strange in the decathlon example, would it not seem strange in other contexts like that of organ allocation as well? If the individual patient is all that matters, would we not insist that the allocation algorithm for kidneys is individualist in the sense that only characteristics matter that are truly individualist rather than merely being ascribed to individuals?

We believe that the basic values underlying our traditional (Western) medical ethics suggest that the allocation rule should be such that solutions of allocation problems determine allocations as a ***function of truly individual attributes.***

The substantial requirement that the solution be a function of truly individual attributes is clearly violated in the organ allocation case. In the Wujciak-Opelz algorithm 'collective' characteristics like regional donation rates $P_4^i(K)$ and import/export balances between national groups of centers $P_5^i(K)$ play a decisive role. Imagine a patient A who dominates for some kidney K another patient B along the first three subscales according to $P_j^A(K) \geq P_j^B(K)$, for $j = 1, 2, 3$ but is dominated by B according to $P_j^A(K) \leq P_j^B(K)$, for $j = 4, 5$. It is quite possible that $\sum_{v=1}^{5} P_v^B(K) \geq \sum_{v=1}^{5} P_v^A(K)$ and the kidney is allocated to individual B. But it would be hardly possible to say that this happens due to individual characteristics of A and B.

In reality, it is no rare event at all that a patient A who is preferred to a patient B, if A is on the waiting list at center X, would end up after B if he were registered at center Y. It is important to note the implicit violation of individualist values to which we otherwise, at least officially, hasten to subscribe. This is not changed by the fact that even non-individual characteristics can, so to say, be attached to individuals. Of course, for any kidney K the characteristics $P_j^i(K), j = 4, 5$, can be included in the list characterizing the individual. However, this inclusion in a list of individual attributes does not make the characteristics into individual attributes in any substantial sense of that term. It is nothing about the individual herself that fixes the values of the subscales 4, 5 of the Wujciak-Opelz algorithm.

4.3.2 Formal Characteristics of the Wujciak-Opelz Algorithm

As the discussion of an axiomatic characterization of the more formal aspects of the Wujciak-Opelz algorithm shows, there are further tensions between the basic individualist orientation of medical ethical codes and present practices of organ allocation. These tensions become apparent on a purely formal level of analysis if we look more closely at some axioms characterizing formal aspects of allocation rules and their solutions.

> Axiom 1: *Impartiality*
>
> An allocation rule is impartial if its solutions depend only on the claimants' types and the set of units to be allocated.

For instance, assume there are three claimants a, b, c of types t_1, t_2, t_3 — a is of type t_1, b is of type t_2 and c is of type t_3—on a waiting list for a transplantable kidney K that has become available. The allocation problem is characterized by $(a, b, c; K)$. The solution of the allocation problem s is a mapping $s : \{a, b, c\} \rightarrow \{0, 1\}$ such that there is exactly one person $i, i \in \{a, b, c\}$, with $s(i) = 1$. This, of course, expresses in formal terms that K is assigned to person $i, i \in \{a, b, c\}$, while all others are excluded.

Impartiality implies that a solution s operating for any list of claimants would yield the same result for any permutation of that list of claimants. To illustrate this, assume that solution s of the zero-one distributive problem $(a, b, c; K)$ fixes $s(b) = 1, s(a) = s(c) = 0$. Function s operating on lists of claimants maps lists of three into zero-one vectors of order three. Impartiality requires that $s((a, b, c)) = (s(a), s(b), s(c)) = (0, 1, 0)$ must imply $s((a, c, b)) = (0, 0, 1), s((b, c, a)) = (1, 0, 0)$, $s((c, a, b)) = (0, 0, 1)$ etc. But more important than the implied permutability of lists of claimants is the underlying condition that only types and the set of units matter. For a better understanding, consider another allocation problem $(x, y, z; K')$ where x is of type t_1, y is of type t_2 and z is of type t_3, while K and K' share identical characteristics such that sets K and K' can be deemed equivalent. Let the solution of this problem be $s' : \{x, y, z\} \to \{0, 1\}$. If the rule is impartial in the sense proposed here, we should have $s'(y) = 1$; that is, kidney K' should be allocated to person y since b and y as well as a and x, c and z, respectively, are of the same type.

For a problem like organ allocation most of us would clearly insist that the allocation procedure should treat individuals symmetrically according to their general characteristics as represented by their types. The axiom of impartiality expresses crucial aspects of this requirement. The Wujciak-Opelz algorithm, though being nonindividualist, is clearly impartial with respect to the individuals. Only the point values determined exclusively for the types of individuals matter (and this is true regardless of the fact that the characteristics underlying scales 4 and 5 are collective in nature and merely ascribed to the individuals).

The chance of receiving an organ depends on the number and types of other individuals on the waiting list. In that sense interdependence between individuals, external effects and interindividual competition of necessity exist. However, according to the individualist thrust of our traditional medical ethics who of any two individuals is to receive an organ K should be decided by the personal characteristics of the two candidates alone. The next axiom captures this requirement.

> Axiom 2: *Pairwise Consistency*
>
> An allocation rule for a class of allocation problems is pairwise consistent if the following holds: For any allocation problem containing types t and t', if the single unit K is to be assigned to one of the two, the solution always assigns unit K in the same way, either to t or t' or there is a tie. What other individuals are assigned and who else in the varying groups of claimants is present does not influence how K is assigned between t and t'.

This axiom links together the solutions for the separate zero-one distributive problems that might emerge under an allocation rule. For a given kidney K allocation problems can differ only with respect to the set of claimants and their types. Imagine two groups of claimants G and G', conceivable under Eurotransplant rules. Pairwise consistency requires that the direct comparison between any two types t and t' that happen to be present in both groups G and G' depends only on the characteristics of those two types and not on whether or not other types are present in G or G'.

The preceding interpretation should suffice to clarify the meaning of axiom 2. But is the requirement expressed in axiom 2 a desirable feature of an allocation rule?

In the decathlon example, we would generally assume that the comparison between any two competitors should not depend on who else is present. For instance, if we had 20 competitors in a decathlon and would only take into account who finishes in front of whom in any of the contests by, say, allocating 20 points to the first, 19 to the second etc., then whether A finishes before B in the decathlon could depend entirely on who else is present. If, say, B wins the one hundred meter dash while A finishes last, then under the ranking point system assumed to apply in this instance, B has the edge over A by 19 points in that specific contest. If, on the other hand, B finishes first and A second in the 100 m dash, then the differential would be only 1 point. Other competitors' results potentially influence the direct comparison between A and B. Even if we keep the results of A and B (their type) fixed in two decathlons under the ranking point scheme adopted here, A could be the winner in one and B in the other contingent on who else performed how in the two decathlon events.

The latter would seem grossly inadequate to most people when comparing individuals and their individual merits. In contexts like the decathlon, the focus is naturally on individuals—or more precisely on types. Today's method of determining a decathlon's winner is therefore quite unsurprisingly pairwise consistent. But in other sports like formula 1 racing this is not the case. In formula 1 racing, how many points the winner gets, is dependent on the final results of the others. This may be acceptable since any way of comparing results across different races seems completely arbitrary. Moreover, formula 1 racing certainly has a stronger team aspect than decathlon competitions. For the performance or the type of the driver depends not only on his or her own effort, but also on the car etc.

For our present purposes, the crucial question is whether the problem of organ allocation is more on the side of the decathlon example or to that of racing. For reasons of scarcity, individual patients cannot be considered separately with regard to their own interests only and thus without regard to the competing interests of other patients. This might suggest that the problem is more similar to racing than to decathlon. On the other hand, we should still see to it that the individualist orientation of Western medicine carries over *as far as possible* to inter-patient competition. Therefore, point tables seem desirable on which values are determined for each individual separately, independently of other individuals. This makes the problem more similar to the decathlon example. In any event, it seems quite natural to require pairwise consistency of procedures of organ allocation.

Still, even the mild condition of axiom 2 tends to be violated in real-world institutions of organ allocation. For example, Young himself points out that the kidney allocation formula that UNOS used in the US some years ago was not pairwise consistent. In this formula, the point values for waiting time depended on the total number of waiting patients (see Young 1994, 33). In the present European system pairwise consistency may be violated, too. For in the Wujciak-Opelz algorithm, the weighted sum of points of a given individual depends on the number or the types of the other waiting individuals in the group of claimants.

In the algorithm, the waiting time point index for all individuals i is calculated according to

$$P_3^i(K) = 2 \times 100 \times \frac{\text{waiting time of patient}}{\text{longest waiting time in the pool}}$$

As long as the longest waiting time in the pool does not change, pairwise consistency will not be violated. Moreover, dividing given waiting times of patients by alternative waiting times will never change the ranking ***according to waiting time.*** Of any two individuals the individual with the longer waiting time will have the higher index number regardless. However, if two individuals have approximately the same index number after aggregating along dimensions other than waiting time, then dividing by a new 'longest waiting time' for example because the patient previously waiting longest has exited the pool—may alter their ranking. The one who has waited longer may now be granted a considerably higher differential in his favor from the waiting time subindex, and this may outweigh the favorable position of the competitor along other dimensions.

Marginal violations of pairwise consistency might be deemed acceptable, while frequent major violations may seem quite discomforting—at least for those who think that interindividual comparisons should be the basis of ranking any two individuals. How frequently this problem emerges depends on how often the waiting time index is adjusted and how close individual point values are along dimensions other than waiting time. It may be suspected though, that the emergence of the problem is not altogether rare since the inclusion of waiting time does indeed affect allocation.

How severe the problem is from a normative point of view depends on how strongly we feel about pairwise consistency. The more individualistically minded will in general support this value more strongly than others. In the case of kidney transplants, they will also be in a position to point out that the problem emerging from the specific way of determining the point value of waiting time can be easily avoided. It need not be made relative to the population of the pool (the longest waiting time in the pool). One can keep the values of the subscale at a specific interval by other means, for instance by some form of discounting longer time spans.

It is clearly desirable to have a pairwise consistent method if possible. "The key is to define each patient's type solely in terms of information about that claimant, and then order the types according to some notion of priority." (Young 1994, 33)

The view that pairwise consistency should be achieved if possible is also supported by the 'intimate' relation of pairwise consistent, impartial methods to common methods of prioritizing. With respect to priority methods, Young proves a basic theorem.

> Theorem 1: A zero-one allocation rule is impartial and pairwise consistent if and only if it is a priority method.

In the specific case of kidney allocation framed here, a new allocation problem emerges with every kidney that becomes available. A new standard of comparison ordering all types in relation to the specific kidney is defined. The individual on the waiting list with the highest priority on the specific priority order of the list induced by the standard of comparison, as defined for the kidney at hand, receives the organ. (The method allows for ties.)

Point systems are special cases of priority methods. Therefore, the question arises which additional property is needed to characterize priority methods whose way of forming priorities can adequately be represented by assigning a point scale separately to every subdimension of the overall problem. These methods then, like the Wujciak-Opelz algorithm, can use weighted sums of point values to determine the priority list.

In answering this question, an axiom of so-called 'pairwise separability' of value dimensions is crucial. Again let us start with a specific decathlon example to illustrate what is at stake here. Afterwards, we will turn to the axiom itself and sketch its application to the case of the Wujciak-Opelz algorithm.

Imagine two competitors t and t' who finish with exactly the same results in all contests of a decathlon except, say, the hundred meter dash and the high jump. The performance of t is characterized by, say, (11 sec., 210 cm) and that of t' by, say, (10.8 sec, 205 cm). So, obviously t loses against t' in the hundred meter dash competition; but t beats t' in the high jump. Assume that according to the overall evaluation criterion competitor t beats t' in the decathlon. Consider now competitors s and s'. Again, both finish with exactly the same results in eight contests except for the hundred meter dash and the high jump. The performance of s and s' in the hundred meter dash and the high jump is the same as that of t and t', respectively, namely (11 sec., 210 cm) for s and (10.8 sec, 205 cm) for s'.

Given these premises, there is nothing but the performance in both cases (11 sec., 210 cm) and (10.8 sec, 205 cm) by which, according to our normal standards of relevance, we can differentiate between t and t' in the first and s and s' in the second case. Since the differences in performance are the same in both cases, we would intuitively require that if t beats t' then s should beat s' and vice versa, *regardless of the performances in the other competitions which are pairwise identical, but possibly differ between pairs.* In short, t should beat t' if and only if s beats s', or so it seems.

In the eight contests in which s and s' show identical results, their performance can be—and as may be assumed here is—different from the identical performance of t and t' in these eight disciplines. The basic normative question is whether the differences in the results, which are identical for t, t' and s, s', respectively, should influence the ranking. If we subscribe to the axiom of pairwise separability, we thereby answer that question, at least implicitly, in the negative.

> Axiom 3: *Pairwise Separability*
>
> Assume that types t and t' are identical in all attributes except for the two attributes α and β, in which t shows a and b while t' shows a' and b', respectively. Assume also that, with respect to attributes α and β the individual s is like t—showing a and b—while s' is like t'—showing a' and b'. Let s and s' coincide, too, with each other in all attributes except α and β while s and s' may differ from t and t' in the other attributes in which s and s' themselves coincide. A priority rule is separable in the attributes α,β if the ranking of t and t' is the same as the ranking of s and s' under these conditions.

The axiom of pairwise separability requires that if the differences leading to the ranking of t and t' are only 'caused' by the attributes α,β and are the same as the differences in the case of s and s', which also differ only with respect to α,β, then the same ranking decision should be made between t and t', on the one hand, and s and s', on the other. If such separation is possible we can rely on the following useful theorem (see again Young 1994).

> Theorem 2
>
> If types of claimants are evaluated according to a finite number of attributes, and if there is a finite number of distinct types, then a priority rule can be represented by a linear point system if and only if the priority rule is pairwise separable in every pair of attributes.

Due to this theorem we know that we cannot have a linear point system without having pairwise separability. So, whoever intends to use the Wujciak-Opelz algorithm must believe that evaluations can be separated at least over the relevant range.

5. Discussion

Allocation systems like the Wujciak-Opelz algorithm can be adequate representations of our substantive evaluations only under certain conditions. The first requirement is, of course, that all and the right dimensions of value be included. Second, we know from theorem 1 that impartiality and pairwise consistency imply that a priority method must be used. Third, according to theorem 2, we know whether and when one of the linear point systems that are so naturally appealing to the human mind will do.

But these normative considerations do not tell the whole story. Besides the values expressed in the background assumption of substantive individualism and the axioms 1–3, there are other dimensions of value involved in the complex practice of organ transplantation. Apart from patients having an interest in a short waiting time and good HLA-compatibility other interests deserve to be mentioned. There is an intermediate level of transplant centers on which we find efficiency goals and claims of having access to an appropriate supply of organs. And there are (arguably) 'collective' interests in maximizing transplant success, minimizing collective waiting time and transport risks etc. Finally, there are broader considerations of fairness in the treatment of individuals and centers.

All this must be taken into account in a fuller discussion of organ allocation in society. Analyses like the original simulations of Wujciak should obviously also be included in our search for a reflective equilibrium on allocation procedures. So, quite independently of how one thinks of the preceding application of general equity theory to organ allocation, a wide variety of issues must still be addressed. In fact, we readily accept that what has been said before may raise more problems than it solves. We also think, however, that in view of the general plausibility of the axioms and analyses outlined above, the burden of proof should clearly rest with those who intend to violate any of the axioms mentioned.

In particular, the inclusion of dimensions 4 and 5 of the present algorithm that are ruled out by the preceding analysis requires very strong arguments. In fact we believe that only imminent threats to the viability of the whole procedure can provide a reason strong enough for including such 'collective' value dimensions in a fundamentally individualist system of medical ethics.

In view of this statement, let us raise the following crucial question: Can we have a viable system of organ transplantation that is substantially individualist, or are violations of the individualist core of western medical ethics necessary to sustain present levels of organ donation?

The argument that an incentive to participate in harvesting organs must be provided for transplant centers is quite plausible. This might suggest that regional donation rates be taken into account. This provides an incentive for centers to realize donations in their regions. Yet, this argument, though plausible at first sight, seems to be rather weak on closer examination. As the experience in the region Niedersachsen/Ostwestfalen seems to indicate, the participation of the transplantation centers in harvesting organs is neither necessary nor even helpful for realizing high donation rates. For several reasons, it seems more efficient to have a specialized unit for this purpose which operates independently of the transplantation centers that eventually receive the organs for their patients.

First, specialization in the task of realizing and furthering donations leads to greater expertise in dealing with the hospitals in which potential donors are to be found. Second, an independent unit can organize donations from the donors' side and for the region in which the organs are to be harvested. Those who donate organize their 'giving' rather than helping in a process in which organs are 'taken' by some more or less remote center perceived as pursuing its own agenda. Third, permanent contact between hospitals and transplant unit will ensure relations based on trust and that explantation will not be disruptive to normal procedures at the hospital with a potential donor. Fourth, as in the case of rescue squads which have to be on constant alert, there are obvious economies of scale involved if the realization of organ donations is conducted by a specialized agency. Fifth, the specialized organization will not lack an incentive to realize donations since its existence depends on providing that service. Finally, as has been shown, the number of realized donations can in fact be increased under a scheme like the preceding one (for all preceding and empirical findings supporting the views expressed here, see Gubernatis 1999).

An independent unit for realizing organ donations could work without any reliance on scale 4. Since it seems empirically clear that it could work at least as efficiently as present systems, the strong normative arguments in its favor should apply with full force. In view of the fact that the collectivist spirit of subscale 4 is alien to the other values of our medical ethics, this subscale should be eliminated from the Wujciak-Opelz algorithm.

But what about the subscale representing international organ exchange rates? Indeed, some kind of substitute for this subscale seems necessary if the system is to be sustained. The risk of causing some national resentment in a sensitive field such as organ donation should not be underestimated, either. Generally, schemes that try to provide collective goods for large groups efficiently over a long period without some sort of relation between contribution and utilization are prone to break down eventually. If, as in organ donation, the solving of some kind of insurance problem is at issue, then 'reciprocity' seems the most natural way of relating contribution to utilization.

In case of the Wujciak-Opelz algorithm, reciprocity is included exclusively on the collective level—in particular between 'nations'. But collective fairness, that is, fairness between nations which desire to strike a fair balance between receiving and passing on organs is much less plausible than interindividual fairness. More specifically, we should ask why it is that the exchange balance between nations is included, while the willingness of potential recipients to donate themselves is not. To put it slightly different, if reciprocity is admitted as a value dimension at all, why is collective reciprocity included, but interindividual reciprocity is not?

The axioms introduced above, along with the individualist spirit of western medical ethics, suggest that if reciprocity is accepted as a value at all then it should be included as interindividual reciprocity. Individual willingness indicated in advance to donate is an individual characteristic that can be 'naturally' included in the type of individuals and can thus be taken into account without violating substantive individualism. On the other hand, collective reciprocity will of necessity violate substantive individualism. Moreover, a patient's willingness to donate is a characteristic that agrees well with pairwise separability as well as pairwise consistency. Individual reciprocity would thus fit in well. Finally, as an aside, it should also be noted that the notorious problem of the rich foreigner making his way into the medical system of another country can be solved in that way in an acceptable manner. As such, the fact that he is a foreigner does as not play a role, only that he is a non-contributor to the system of reciprocal solidarity (for more economically minded analyses of reciprocity schemes, see Breyer/Kliemt 1994; Kliemt 1993).

As we have argued elsewhere, granting some priority in the role of organ recipients to those who have been and continue to be willing donors can easily be accomplished by including a subscale granting points as a function of the time that elapses between declaring willingness to donate and the necessity to receive an organ. This rule also puts patients in a position to exert some moral pressure on hospitals to realize potential donations. For after such a change of regime, patients are no longer merely the object of acts of altruism and solidarity. They become subjects of a process in which they have played their part. Having made their contribution, they can demand that others will assist them in satisfying their own needs (for a fuller account of an appropriate modification of the Wujciak-Opelz algorithm, see Gubernatis/Kliemt 1999; on including interindividual reciprocity in organ allocation, see also the presumably earliest proposal to that effect made directly after the first heart transplant by Lederberg 1967).

It is a central merit of the Wujciak-Opelz algorithm that it is intersubjectively valid in the sense of not leaving much discretionary power to doctors or bureaucrats. This feature can be upheld if individual willingness to donate is included as a subscale of the algorithm instead of the previous subscales 4 and 5. With such a modification, the Wujciak-Opelz algorithm seems, in principle, much more acceptable than without it. Including dimensions 4 and 5 in the

Wujciak-Opelz algorithm may have been wise pragmatically, but it is hardly defensible on systematic grounds. In view of German law, these dimensions will have to be eliminated anyway since the law requires that organ allocation be decided exclusively on medical grounds. Though lawyers are quite ingenious in reinterpreting the law, they would have a hard time arguing plausibly that national exchange rates of organs are medical criteria.

However, our own proposal relies on nonmedical criteria as well. So on this front, our reform proposal does not have the upper hand. Nevertheless, if the law has eventually to be amended anyway, why not change it in a reasonable direction. In our view, the law should insist only on the intersubjective validity of the criterion. (Perhaps the law should also provide for an institution that is authorized within some constraints to fix the dimensions and relative weights of an allocation algorithm, Eurotransplant being the obvious candidate.)

We think that implementing an allocation procedure like the Wujciak-Opelz algorithm, which directly assigns organs to individual patients, has been a major step forward. The intersubjective validity of the procedure is an essential aspect of sustaining the acceptance of organ donation in the population at large. But besides controllability, there are other conditions that should be met if a procedure is to be widely acceptable. Intuitive plausibility is another very important element.

Designing a scheme that seems intelligible and acceptable to the general public is particularly desirable in the case of organ allocation. Since the general public will in general feel hard-pressed to accept anything more complicated than a simple linear point scale we are presumably stuck with this functional form. If that is so, we must ask how we can use such a scale best as approximation for expressing basic values. But in doing so, we must first understand what we are doing. For that purpose, we must engage in systematic reflections of the type presented in the preceding discussion. As a next step, we must address the substantial issues of which scales to include and of how to weigh them against each other. As far as the allocation should reflect medical expertise, we must provide a systematic way of including that expertise. We must show how the algorithm can be evaluated on the basis of what the experts know and believe. As far as nonmedical values and criteria enter into the process, it should also be assessed how the views of informed laypersons, patients etc. are reflected in the algorithm.

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