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The Deceased Transplant Recipients: A Forgotten Source of Organ Donors

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Abstract: Background: Organ transplantation is the most successful therapy for end-stage organ disease since it increases the quality of life and life expectancy. For these reasons, over 107,000 patients were on the waitlist in the United States for a transplant in 2022. Unfortunately, only 42,887 transplants were performed, and annually, over 7000 patients on the kidney list die or are too sick to transplant. To solve this severe organ shortage, the use of the deceased transplant recipients with functioning organs, whether transplanted or native, is explored as a new source of organ donors. Methods: To assess the feasibility of this option, first, we will review the rate of kidney transplant recipients dying with functioning grafts (DWGF), their re-use, the organ allocation system, the technical aspects of the organ procurement, and the transplantation of the DWGF kidneys. Then, we will consider the larger group of all deceased transplant recipients as potential donors for all functioning, native, or transplanted organs. Conclusions: (1). All functioning kidney transplants explanted from the deceased transplant recipients have excellent long-term function after re-transplantation. (2). The other functioning organs constitute a large unrecognized pool of transplantable organs. (3). The intensivists and the transplant community should be educated about these new options to improve the organ shortage.

Keywords: deceased transplant recipient; explanted transplants; re-used transplants; organs from transplant recipients; recycled organs

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1. Introduction

Despite the recognized success of renal transplantation as a therapy for end-stage renal failure, the severe lack of organs remains a major hurdle to transplantation. In the United States, there were over 107,000 patients on the waiting list for a solid organ such as a kidney, a liver, a heart, or a pancreas as of 15 March 2023 [1]. Unfortunately, only 42,887 organs from 14,903 donors were transplanted in 2022. The largest group of 88,831 patients are on the waitlist for a kidney, with 25,499 patients receiving 19,636 kidneys from deceased donors and 5863 kidneys from living donors [1]. The median waiting time for a transplant is 3.9 years and is longer for patients with blood group B or O or elevated levels of sensitization. Forty-seven percent (47%) of patients were removed from the list within 5 years because of death or health-related morbidities preventing them from being listed. Compounding further the organ shortage is the aging of the donor population and the poorer quality of the donor kidneys. In the same vein, 15,000 patients waited for an average of 321 days for a liver, with only 9230 transplanted annually. There were 4111 heart transplants performed after a waiting time of 31–180 days.

The first alternative to the conventional living donor and the standard deceased donor kidneys described to date is a functioning transplant kidney from a deceased transplant recipient (Death with Graft Function, or DWGF). To assess the feasibility of re-using a transplant kidney, it is reasonable to review the incidence of transplant recipients dying with normal graft function; the historical development of this unrecognized and underdeveloped type of kidney transplant; and the problems arising with its use, including the donor

criteria, the histocompatibility testing, the technical aspect of the organ procurement, and the transplantation procedure itself. Results from the re-used kidneys and the allocation of this special "extended criteria donor kidney" will be discussed. The transplantation of a special group of kidneys affected by thrombotic microangiopathy (TMA) and focal segmental glomerulosclerosis (FSGS) will be mentioned.

The next option is deceased transplant recipients who can donate *all functioning organs*, native or transplanted, for transplantation.

1.1. Incidence of Death with Functioning Grafts (DWGF)

West et al. from Minnesota [2], following 1932 kidney transplants performed between 1 January 1985 and 31 October 1994, reported that 220 patients (10%) died with functioning grafts, with a mean serum creatinine level of less than 2 mg/dL at the time of death. The cause of death was infection (22%), myocardial infarction (17%) and sudden death (15%). Ojo et al., reporting on 86,502 adults (>18 years) transplanted during the years 1988–1997 from the data of the United Network for Organ Sharing and Scientific Renal Transplant Registry and the United States Renal Disease System (USRDS), noted that 18,482 patients died during a mean follow-up of 30 ± 28 months. Of these, 7040 or 38.1% had a functioning graft with a mean serum creatinine level of 1.9 ± 0.8 mg/dL [3]. With advanced knowledge in the use of immunosuppression, the causes of death have shifted, and cardiovascular disease has become the leading cause of death in 42.3% of patients, followed by infection (17.6%), malignancy (9.2%), and others such as gastrointestinal diseases, accident, and suicide. As expected, recipients older than 65 years at transplantation were seven times more likely to die with a functioning graft (RR = 7.02, $p < 0.001$) than the 18-to-29-year-old group. The mortality from cardiovascular origin was most pronounced in diabetic recipients with a two-fold higher rate than any other group. Qui et al. found out, from the Organ Procurement and Transplantation Network and the United Network for Organ Sharing data between 1988 and 2004 with 217,670 recipients, that DWGF occurred in 3% in the first post-transplant year and increased by 6.5% yearly between the second and fifth year post-transplant. DWGF also increased significantly with increasing recipient age among both deceased and living donor kidney recipients [4]. Of 23,210 recipients from the Australian and New-Zealand Dialysis and Transplant Registry data (ANZDATA), 4765 died with a functioning graft, with an incidence of 20.5% [5]. This is in keeping with the report of Didier et al. who, after comparing 17,526 transplant recipients to a cohort of 3,288,857 non-transplanted persons from the Nationwide French Medical Information Database, reported that transplant recipients more frequently developed myocardial infarction than the non-transplant group [6]. In a recent study of 14,453 patients under immunosuppression with cyclosporine, tacrolimus, mycophenolate, IL2 receptor blockade, and cytolytic induction, de Teresa A et al. reported that "death with a functioning graft is still the most common cause of kidney transplant loss", with an incidence of 16.9% at 6 months and at 10 years [7]. Gaston et al., in a study of 3587 patients over >18 years of age, reported 9.8% of patients dying with a functioning graft [8].

El-Agroudy et al., following 1400 living donor kidneys from March 1976 to January 2002, reported that the main causes of death with functioning graft were infection (35.6%), cardiovascular events (17.6%), liver cell failure (17.6%), and malignancy (6.1%) [9]. Among these patients, 131 patients died with a functioning graft (8.7%). The median time from transplantation to death was 37 months (mean 53.4 ± 53.2, range 1–203). The most recent serum creatinine level prior to death was 2.0 ± 0.6 mg/dL and was <2 mg/dL in 69.4% of patients. Infection and sepsis remained the leading cause of DWGF with a decreasing level, from 37.5% in the 1970s to 28.8% in the 1990s. Cardiovascular complications were the second-leading cause of DWGF with an increasing rate from 12.5% to 17.2% in the same eras. Gamal et al., in a follow-up of 2953 patients receiving a living donor kidney for 8.47 ± 5.76 years (range 0–33.54 years), noted an incidence of 9.9% of DWGF [10].

Taken together, the rates of DWGF in long-term transplants range from 8.7% to 38.1%. The rate is ten times higher for recipients over the age of 60 than for young recipients under

the age of 18. It will continue to rise since the proportion of adults >65 years of age undergoing transplantation increases constantly, due to the advancements in immunosuppression pharmacopeia and surgical techniques. Good cadaver kidneys are more likely to be available for re-use since the mean age of cadaveric donor kidneys going into older recipients is only 23.84 years. The living donor kidneys, with a mean age of 52.75 years, are more likely to be transplanted to younger recipients and will have longer survival [11]. Most importantly, these data provide compelling evidence that there is a significant underused pool of good transplant kidneys for re-use that needs to be evaluated and procured for transplantation.

1.2. Historical Aspect of Transplantation of the DWGF Kidneys

The first re-used kidney was reported in 1987 by Al-Hasani et al. from the Renal Transplant Unit of the University of Groningen, Groningen, The Netherlands, based at the Armed Forces Hospital in Riyadh, Kingdom of Saudi Arabia [12]. It was offered via Euro-transplant in Holland and came from a 56-year-old Dutch woman who received a transplant six months previously and who died from a head injury with a serum creatinine level of 125 micromoles/L (1.4 mg/dL). It was transplanted into a 64-year-old Saudi man after a cold ischemia time of 43 h. The biopsy at time of transplantation showed only mild acute tubular necrosis. Immunosuppression consisted of cyclosporine and corticosteroids. The kidney opened up after 3 weeks of dialysis. The patient recovered from two episodes of sepsis with Salmonella Typhi. After five months, he was doing well with a serum creatinine level of 132 micromoles/L (1.5 mg/dL).

The small number of case reports scattered during the last three decades [13–32] did not catch the attention of the transplant community until analyses were published from the organ transplant agencies on both sides of the Atlantic [33–35]. Lowell et al., with data of the United Network for Organ Sharing and The Scientific Transplant Registry, reported findings on forty-eight recipients of previously re-used kidneys transplanted between October 1987 and June 1996 and compared them to those of 68,568 patients receiving native organs during the same period [33]. There was no difference in the incidence of graft rejection and graft survival in the two groups, with p = NS and p = 0.20, respectively. Lee et al. [35] extended the previous search to 30 June 2015, with 517 donors and 397 explanted transplant kidneys, with a 7.8-fold increase in re-used organs. This consisted of 109 from living donors, or 34.9%, presumably with excellent function and anatomy [26]. Of all organs procured, 128 kidneys were re-used (24.8%), with a mean serum creatinine level of 0.9 (0.7–1.2) mg/dL. There were 208 kidneys not recovered (40.2%) with a serum creatinine level of 2.99 (1.8–5.6) mg/dL, 11 kidneys (2.1%) recovered but not for transplant (9.7%) with a serum creatinine level of 4.8 (2.4–6.2 mg) mg/dL, and 50 kidneys or 9.7% recovered for transplant but were not transplanted with a serum creatinine level of 1.2 (0.8–2.07) mg/dL. This large gap of unused good kidneys may be explained by the presence of surgical damage occurring during the unusual explanation procedure and the low acceptance of the novel re-used kidney. Karakizlis et al. [32], with the Euro-transplant data between January 1995 and December 2015, identified 9 DWGF kidneys amongst 68,554 recipients. Four of these were transplanted successfully, with grafts surviving between 3 and 18 years. The scarcity of data gleaned from both registries reflects the lack of anticipation about the re-use of the organs, hence the paucity of the information built into the questionnaires at the time of the re-use and the lack of information about the rate of delayed graft function and the immunosuppression used at the time of reporting. Incomplete as it was, the information did show that the re-used organs provided good long-term results and should be considered more often as a new source of organs.

1.3. Selection of the DWGF Kidneys

The median age for DWGF donors in the UNOS registry was 47 (IQR: 38–57), with 34.9% being living donor kidney transplants [26]. In the European data, the mean age of the first donor was 32 years, with a range of 18–54. The mean age of the second recipient

was 66 years (range 65–67). However, the mean age of the re-used graft was only 36 years (range 23–54), similar to that of the original donor. All kidneys functioned immediately without dialysis, suggesting that the transplant procedure was well planned and the cold ischemia time was short [33]. With the use of steroids, the transplant patients developed new and accelerated cardiovascular morbidities related to increased rates of diabetes and hypertension compared to the general population [6]. They are also exposed to a higher incidence of cancer due to chronic immunosuppression and a plethora of infections caused by viral, fungal, bacterial, and parasitic organisms [22,23]. The use of calcineurin inhibitors is known to contribute to chronic kidney injury [27]. Taken together, these morbidities may explain the inferior outcome of the re-used kidneys from donors surviving for >1 year and the possible indication for pre-transplant biopsy, which is rarely performed in the clinical setting.

The time of graft function in the first recipient does not portend any relationship with the graft survival of the second recipient. There have been reports of long follow-up after re-transplantation of 4 to 18 years with good re-used graft function (serum creatinine level of 1.3 mg/dL) after a long graft survival of the first transplant lasting 6 to 10 years [18,20–27]. Conversely, a short graft life of the first recipient does not influence the length of graft survival in the second recipient or makes them at increased risk of graft loss, as in the case of a 36-year-old who died of a cerebrovascular accident two months after a successful transplant [28]. His explanted kidney was retransplanted into a 65-year-old patient who was still in good health 18 years later with a serum creatinine level of 1.2 mg/dL and normal range of proteinuria (30 mg/dL).

The low estimated glomerular filtration rate (eGFR) of a single kidney transplant does not have the same connotation as the eGFR of a conventional donor who has two kidneys and should not be a reason to reject an organ for re-transplantation. This was demonstrated by the fact that recipients of long-term re-used kidneys were reported to have a serum creatinine level of 1.27 mg/dL compared to 1.0 mg/dL in the original donors [33]. Despite the multiple semantic discussions involved in its determination, the glomerular filtration rate still remains the gold-standard clinical parameter of renal function. Thus, the selection criteria of a re-used donor kidney are exactly those of a conventional donor kidney i.e., the absence of intractable infections and transmissible cancers and good renal function. A confirmative biopsy was advocated by some to rule out major chronic damage prior to re-use.

Information provided by biopsy at the time of procurement was thought to help the transplant physician make a decision about the use of “a less than ideal kidney” or a ”high-risk kidney” for transplantation. Pre-transplant biopsies were reported by Nghiem [36] in 1992 to prospectively assess the histologic quality of kidneys from donors 40 to 67 years old (average 52 years). Wedge biopsies yielded a mean of 6.6 sclerotic glomeruli among a total of 44.8 counted glomeruli per slide, with a 14.7% incidence of glomerulosclerosis, whereas needle biopsies yielded only half of that number without the high incidence of cortical glomerular sclerosis. The latter does not reflect the true histology of the kidney since it involves less than 30 glomeruli. The kidneys provided a graft survival rate of 76.4% at 4 years with a stable serum creatinine level of 2.2 mg/dL, which is in agreement with the results reported by Sumrani et al. with elderly living related donors having serum creatinine levels of 2.2 mg/dL at 3 years [37]. Studies by Kaplan et al. of 1.0 × 2.0 cm full-thickness biopsies of the cortex (subcapsular, middle level, and inner cortex zones) in 122 patients with normal renal function showed an incidence of 7.1% to 12.5% sclerotic glomeruli and a predicted incidence of 23 to 27% sclerosis in the kidneys of patients 50 to 80 years old [38]. The systematic and non-justified use of a glomerulosclerosis rate of 25–50% as a cut-off value has led to an annual discard rate of 17% of deceased donor kidneys in the US. To date, no study has found an association between graft survival and glomerulosclerosis [39]. The pre-transplant biopsy of a re-used kidney advocated by some centers has shown the presence of acute tubular necrosis [12]; thrombotic microangiopathy [31]; microvascular thrombosis [40], herpetic viral inclusions [22]; chronic calcineurin toxicity calling for the

use of Sirolimus [27]; and focal segmental glomerulosclerosis [23]. No kidney has been reported to be turned down due to poor renal histologic findings, and no failure of a re-used kidney has been reported to date [34]. The likely reasons for discarding a re-used kidney were decreased renal function, severe arteriosclerosis of the graft arteries, and chronic hepatitis [9].

1.4. Allocation of the DWGF Kidney

The DWGF kidney may be considered a new type of extended criteria kidney donor, along with other donors over 60 years of age, with hypertension, diabetes, a terminal serum creatinine level >1.5 mg/dL, or death from cerebrovascular accidents [34]. In the US, all kidneys are allocated according to the Kidney Donor Profile Index (KDPI) policy implemented in 2014 [41–43]. The calculation of the KDPI includes ten variables that influence organ quality and nephron mass: age, height, weight, cause of death, i.e., brain death vs. cardiac death, last serum creatinine level, diabetes, hypertension, HCV infection, and ethnicity. This system has proven to be complicated and outdated since it failed to capture all recipients requiring a transplant and several types of donors, such as DWGF donors. In this instance, the KDPI is not accurate when a young donor is recorded using the data from an aged DWGF donor at the time of re-use. The addition of the estimated post-transplant survival (EPTS) to the allocation equation in Dec 2021 further complicates the distribution scheme and the kidney utilization [44]. Particularly, the case of re-used kidneys affected by severe thrombotic microangiopathy (TMA) and focal segmental glomerulosclerosis (FSGS), albeit rare, will need further clarification at the time of allocation. The use of the KDPI has led to over 7000 kidneys being discarded annually in the United States [43].

At the time of transplant, the recipients were fully informed about the unusual kidney transplant donor as well as the potential risks and complications of the rare transplant procedure. They all accepted because they had been waiting on dialysis for 7–9 years and had witnessed the deaths of their dialysis-dependent friends [25].

As there are no viable cells from the original donor at the time of kidney re-use, no micro cytotoxicity crossmatch between the original donor and the second recipient is possible. Hence, the second recipient should be checked to ensure that they do not have performed specific antibodies to the original donor which can be detected via a "virtual crossmatch" using beads coated with multiple HLA antigens. For this immunologic reason, it is preferable to select a non-sensitized recipient for the re-used kidney. This will be described further in Section 1.5.2.

1.5. Technical Aspect of the Organ Recovery and Transplantation of the DWGF Kidney

1.5.1. Organ Procurement

It is known that chronically rejected kidneys generate a lot of peri transplant adhesions, meaning their removal can only be best conducted by staying within the capsule of the kidney to avoid tedious and difficult extracapsular dissection [45]. Conversely, in transplant patients taking steroids, it has been observed that adhesions are minimal, and the renal vessels still remain soft, to the extent that they can be used during orthotopic re-transplantation without the need of dissecting out the host vessels for vascular anastomosis [15,25,46]. The minimal adhesions allow a normal organ procurement process except for the continuous protective cooling of the kidney during the explanation of the transplanted kidney. During the recovery of the DWGF kidney and other intra-abdominal organs, a midline approach is used as usual. The arterial perfusion cannula is inserted in the *contralateral* iliac artery to cool the intra-abdominal organs and the transplant kidney to be explanted. Venting is carried out through a cava venotomy. After the procurement of the intra-abdominal organs, with the distal aorta still clamped, the transplanted kidney is continuously perfused with cold perfusate until it is removed. The ipsilateral iliac vessels are dissected from the aortic bifurcation to the inguinal ligament and removed en bloc with the kidney, the ureter, and the periureteral tissue [15,18,25]. A wedge biopsy of the

kidney is mandatory, with a frozen section read by a pathologist knowledgeable in renal transplant histology, rarely available in non-academic centers, to assess any prohibitive chronic damage of the kidney prior to its use. The retrieved explanted kidney is to only be dissected on the back table at the receiving transplant center prior to transplantation.

1.5.2. Histocompatibility Testing and Immunosuppression

Since viable cells from the first long-term donor kidney are no longer available at the time of the transplantation of the explanted kidney, a virtual crossmatch must be performed to determine whether the second recipient has developed any donor-specific HLA antibodies to either donor [25,28,29]. A final complement-dependent cytotoxicity crossmatch between the deceased transplant donor kidney and the second recipient is also necessary since vascular and mesenchymal cells of donor origin with a Y chromosome have been identified in male recipients [30]. This is best performed using a sensitive flow cytometry crossmatch [28,29]. Both anti-HLA antibodies and a final cytotoxic crossmatch with the deceased transplant donor have to be negative prior to the re-use of the explanted transplant. The "virtual" crossmatch simplifies and facilitates the allocation process and reduces the cold ischemic time of the explanted kidney. For these reasons, a non-sensitized recipient is usually chosen. Quadruple drug immunosuppression with a short course of steroids is used to allow rapid healing, in conjunction with the use of depleting antibodies and mycophenolate to avoid rejection and to minimize the toxicity of calcineurin inhibitors. To this effect, the mammalian target of rapamycin, Sirolimus^{R}, has been promoted for the long-term maintenance of the re-used organ with calcineurin toxicity [27].

1.5.3. The Transplantation Procedure

On the back table, the kidney is flipped 180 degrees to facilitate the dissection of the posterior donor iliac vessels without the need to identify the renal vessels. The distal ureter is identified but not skeletonized to avoid pyelo-ureteral devascularization. When ischemia is suspected, 60 cc of new perfusate mixed with one ampule of indigo carmine is injected under low pressure in the proximal donor iliac artery stump to visualize the whole organ [47]. The immediate lack of blue dye observed at the freshened tip of the ureter denotes an ischemic ureter, which requires a special approach. The delayed staining reflects tissue diffusion of the dye and gives false assessment. The kidney is reflushed with new perfusate afterwards. The kidney is placed in the iliac fossa as in a standard transplant operation. In general, the donor iliac vessel stumps proximal to the transplant renal artery and renal vein are closed with fine monofilament sutures, and the distal vessels are anastomosed end to side to the recipient external iliac vessels (Figure 1). A new ureteral reimplantation to the bladder is performed through an extra-vesical Gregoire–Lich technique or a pull-through technique to minimize the trauma of ureteral manipulation [48]. In the case of a short ureter, the transplant is positioned very low in the pelvis to allow the ureter to reach the bladder without tension. In this instance, the iliac vessel stumps bearing the explanted kidney are closed off below the renal vessels, and the proximal donor iliac vessels are used for revascularization (Figure 2). If the ureter is ischemic, a pyelo-ureterostomy using the ipsilateral native ureter is the safest option. Worst comes to worst, a pyelo-cystostomy can be performed as described previously [49]. In all instances, the use of a small #2 French double J stent is preferred to provide ureteral decompression and healing. The #6 French ureteral stents used in normal adult ureters have been reported to disrupt the anastomosis at the time of retrieval. The stent can be removed six weeks later during a clinic visit.

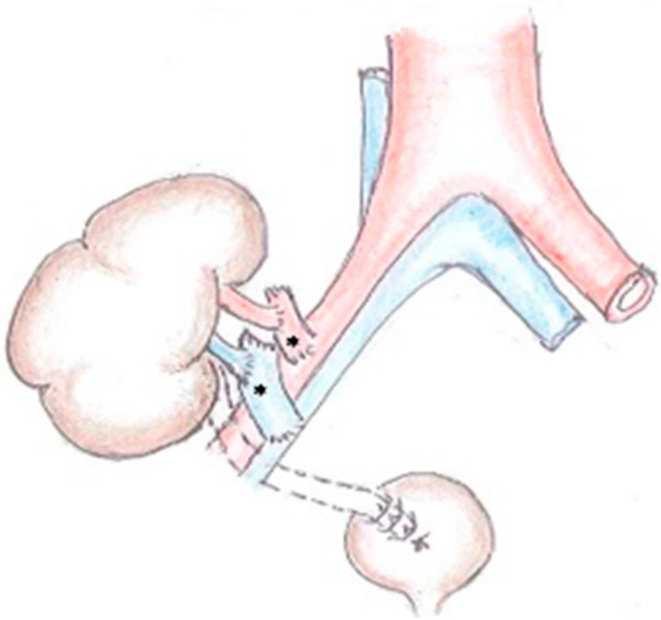

Figure 1. The explanted transplant kidney is shown, vascularized by the stumps of the donor iliac vessels marked by (*) and bearing the renal vessels of the explanted kidney. The ureter is reimplanted according to the pull-through technique. For clarity, the small double J stent was left out, and the ureter is shown in transparency.

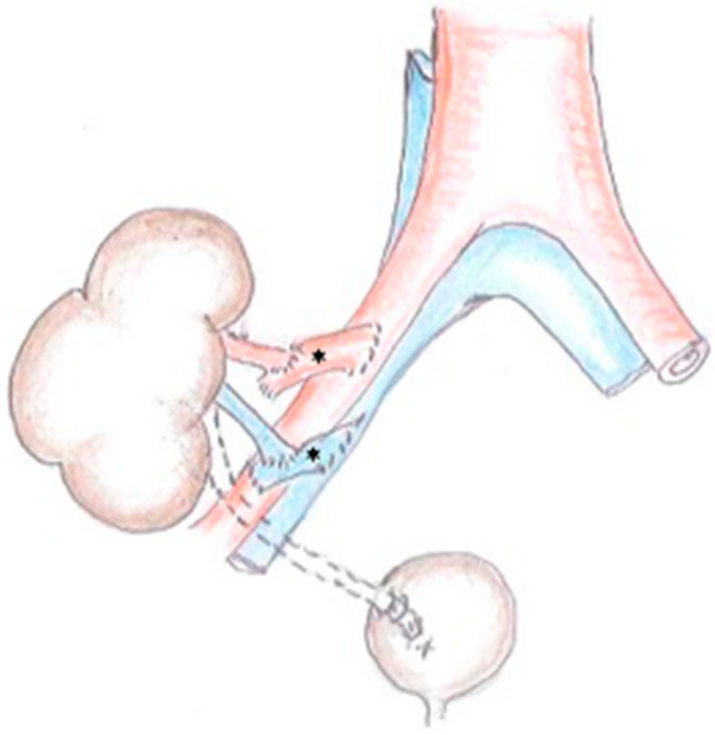

Figure 2. When the transplant ureter is short, the explanted transplant kidney is positioned low in the pelvis to allow the ureter to reach the bladder without tension. For this purpose, the donor iliac vessels (*) are closed distally to the renal vessels, and the proximal donor iliac vascular stumps are anastomosed to the recipient iliac vessels.

1.5.4. Function of the DGWF Kidneys

The DGWF donors had a median serum creatinine level of 0.9 (range 0.7–1.4) mg/dL at the time of their demise. Most re-used organs were transplanted during the recent period 2005–2014. The median graft survival time was 1475 days (range 655–2227) for living donor kidney transplants and 1382 days (range 390–2553) for deceased donor kidney grafts. Re-used kidneys were treated for rejection within the first year after transplant (15.2%) in significantly higher numbers than conventional kidney recipients (9.6%, $p = 0.047$) and had a significantly lower 5-year graft survival rate if they had been surviving more than 1 year in the first host ($p = 0.014$), most probably as a result of prior exposure to toxic doses of calcineurin inhibitor and rejection episodes. Both conventional and re-used kidneys transplanted for less than 1 year had similar graft survival rates of around 75–78% at a mean of 5 years, whereas those kidneys from donors with long survival time demonstrated 5-year survival of 60% [35]. When one considers that the 5-year survival is roughly 40% for patients on hemodialysis and 50% for those on peritoneal dialysis, with over 7000 individuals on the waiting list dying or too sick to transplant annually, the re-used kidneys certainly have provided an opportunity for many transplant candidates to have a reasonable quality of life expectation.

1.6. The special Case of the Domino Transplant Affected by TMA and FSGS

Kamar et al. described, for the first time, a deceased donor kidney affected by recurrent TMA in 2007 [31]. This pathologic lesion is characterized by the presence of microangiopathic hemolytic anemia, thrombocytopenia, and ischemic organ dysfunction or injury from endothelial injury. It is caused by autoantibody or antibody-mediated complement dysregulation or induced by drugs, pregnancy, malignancies, transplantation, infections, and defects of cobalamin metabolism. Microalbuminuria of 1.2 gm/dL occurred within a few weeks after transplantation despite intensive therapy with plasma exchanges, steroids, and rituximab. Transplant nephrectomy is the ultimate option to treat the disease. It was decided to remove the kidney and to retransplant it to another recipient to avoid wasting a functioning and mildly damaged kidney on biopsy. After informed consent of the patient and the potential recipient with terminal polycystic kidney disease and the approval of the French Agency of Biomedicine, the kidney was explanted and retran32lanted into the patient with polycystic kidney disease. The transplantation procedure was uneventful, and at 6 months, the new recipient had serum creatinine of 1.6 mg/dL, microalbuminuria of 0.5 mg/dL, and mild glomerular lesions on biopsy. After the allograft nephrectomy, the donor's hematologic TMA symptoms resolved rapidly. Thus, the kidney functioned well after it was retransplanted into another recipient who may not have had the causal genetic abnormality. This unique therapy was not mentioned in a most recent review of TMA in 2022 [50].

Focal segmental glomerulosclerosis (FSGS) is a histologic lesion characterized by extensive injury of the podocyte due to a putative circulating factor caused by genetic mutations in genes that encode for proteins expressed mainly in the podocytes. Secondary FSGS results from inflammation, drug toxicity, or viral infection. The presence of an FSGS lesion in a kidney biopsy by itself does not establish a diagnosis but should initiate a search to identify the specific etiology leading to the appropriate treatment. The re-use of a transplant kidney affected by early recurrent focal segmental glomerulosclerosis in a living donor was first reported in 2012, by Gallon et al. from Chicago, to simultaneously cure the disease in the donor and give a new life to the new host recipient [24]. The unusual procedure was replicated successfully in two other patients [25,32]. These events strongly suggest that FSGS is a disease of the host, and retransplanting this kidney affected by FSGS into another recipient devoid of the circulating factor would obviate the problem.

1.7. Organs from the Deceased Transplant Recipient

One should consider re-used DWGF kidneys in the context of a larger organ procurement theme which has been overlooked for three decades, i.e., the transplantation

of *all functioning organs* of the deceased transplant recipient to combat the severe organ shortage. The first use of both kidneys from a deceased cardiac transplant recipient from an intracerebral hemorrhage was reported by Nghiem in 1993. Both kidneys with massive intraglomerular microthrombi on biopsies were transplanted successfully in two patients with good function [40]. This was followed by another report, from the same transplant unit, of the successful use of other functioning organs from deceased transplant recipients in 1997 [15] and a review by Arvieux in 1999 [51].

The subject of organs originating from previous transplant patients has only been briefly addressed a few times in the past [13–32]. A comprehensive analysis of OPTN/UNOS data from January 2005 to December 2014 identified 803 organs, native and transplanted, procured from deceased transplant patients [35]. There were 305 kidneys, 84 livers, 60 hearts, 58 lungs, and 10 sets of multiple organs. The re-used kidneys have been discussed in Section 1.2.

The first re-used livers reported by Moreno et al. survived for 25 months, 48 months, and 4 months, respectively [52]. In the collective reviews, the liver donor median age was 25 (range 17–47) with a bilirubin level of 0.7 md/dL (range 0.4–1.1) [27,28]. The MELD median value was 19 (IQR: 14–28) vs. 20 (14–29) for a conventional liver recipient. The graft survival time was 5 days (range 2–45). The recipients were 57 years of age (range 49–61). Overall, the 1-year, 3-year, and 5-year survival rates after liver graft re-use were 93.4%, 80.5%, and 64.4%, respectively, similar to those of standard donors, after a median follow-up of 16 months (1.3–125 months). Similar to the re-used kidney, an explanted liver requires a biopsy to rule out any micro vesicular steatosis, chronic damage, or neoplasia [52–54].

With regard to the hearts and the lung, the number is still too small to draw any conclusions, but their 5-year graft survival rate were not significantly different from conventional grafts, with 75% and 52%, respectively [35].

Taken together, donated organs from the deceased transplant recipients have been doing as well as those from the conventional deceased donors. Since UNOS only collects data of donors donating at least one organ, it is reasonable to assume that, if the annual transplant recipient attrition rate due to cardio-vascular disease and respiratory failure is a conservative 20–25%, one would expect to have 8577 (42,887 patients $\times$ 20%) deceased transplanted donors to 10,782 (42,887 patients $\times$ 25%) deceased transplanted donors. In addition to the UNOS conventional donors of 14,903, the total number of donors would be estimated to be 23,480–25,685 deceased transplant donors. As one donor provides 2.5 organs vs. 2.9 per UNOS data, one would have more organs to transplant all patients on the waitlist [1].

2. Conclusions

There is ample evidence that (1) the re-used kidneys provide normal long-term function after being re-transplanted in the second recipient; (2) they constitute a sizable source of transplantable organs with a 20–30% annual recipient attrition rate due to cardiovascular and pulmonary events; (3) they are only a fraction of a larger group of all native organs that deceased transplant recipients can donate for transplantation; (4) this cohort of deceased recipients can provide good long-term functioning organs to all patients on the waitlist, and finally; (5) efforts should be developed to familiarize the public, the intensivists, and the transplant community with this option to combat the severe organ shortage.

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