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Scoring systems of kidney donation from deceased donors: A systematic review

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Abstract:

Renal disease is the most prevalent disease. Kidney failure can cause physical problems. Hence, patients need to use dialysis therapy or kidney transplantation, and actually, people are in the waiting list for a transplant. This research aimed to extract the prognostic models that evaluate the preparation of kidney donors diagnosed with brain death (DBD).This research was a systematic review of PubMed, Science Direct, and general explorers up until 2020. It followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-P protocol. The assessment of the articles was done by the authors. This evaluation was supposed to be in the form of scoring, prioritizing, and ranking the donors in terms of their preparation. Eleven sources of information included 9 academic articles along with 2 Grey Sources from 7 different countries. 9 algorithms and models were extracted which included, overall 10 factors. All the models were comprised of 4 factors and about 90% of these models considered 4 or 5 factors to evaluate the preparation of kidney donors DBD. Over 60% of the models had taken into account age, blood pressure history, and creatinine factors. Disease prognosis facilitates a doctor's decision-making on the emergence of the disease. Prognostic models of renal diseases can be a great help to patients. A review of the related literature revealed that all the models received a high score in terms of the two factors they included, age and history of blood pressure.

Keywords:

Deceased, donation, donors, kidney, prediction, review, scoring, system, transplant

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Introduction

Millions of people die annually due to a known chronic disease.[1] Renal disease is about the most prevalent diseases which can, at the final stage of the kidney failure, cause many physical problems such as cardiovascular disorders and hypertension.[2] They, therefore, need to use dialysis therapy or kidney transplantation. The latter is considered the most effective treatment of chronic kidney failure and is currently known as the main therapy used for end-stage renal disease patients.[3] The anticipation of the global growth of dialysis patients and those in the waiting list up to 2020 shows that the population of these patients will soon reach four million.[4] This attests to the significance of transplantation. On the other hand, donation mainly depends on those DBD. As statistics show, more than 3% of those who die in hospital experience this condition. Therefore, the number of potential donors is limited. Even once one is DBD, the next stage, which can be more difficult. Donation is a complicated process and requires the cooperation of many health-care providers. Moreover, the whole process is carried out within a short time.

Currently, besides Iran, the number of renal patients is ever increasing at a global scale.[5] Only in the U. S., there are more than a hundred thousand people in the waiting list

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for a transplant. In 2011, about 33 patients were newly added to this list and about 28 thousand were excluded from the list.[6] Among these, about 5 thousand were excluded due to an early death. In other words, when about 5 thousand lost their lives due to renal disease, about 5 thousand others joined the wait list. Worldwide, the kidneys required for renal patients are often supplied in three ways: those DBD, philanthropic donors, and kidney transaction. The key point about the last way of kidney supply except for Iran in all other countries this transaction is unauthorized.[7,8] Therefore, kidney transaction is done illegally and in complicated ways in other countries where two donors often exchange kidneys.[9]

A key sign of medical advancement in recent decades has been the replacement of main body organs through transplantation. Although the transplanted kidney can be supplied by the living, those DBD can also meet the donation conditions. The main point to be considered in supplying transplanting organs is its scarcity. That is why in such countries as Spain today, the majority of transplanted organs are supplied by brain death. This would be made possible through effective education networks and coordinators.[10-12]

The clinical score for finding kidneys from donors DBD with a high risk of dysfunction after the transplant can be a useful instrument to guide the introduction of new algorithms for restoring this organ and improve the postsurgical outcomes.[13] One effective way used today to find a good-quality kidney from a brain dead donor is the scoring of all factors involved in selecting the kidney to be transplanted. Accordingly, different countries have suggested different statistical methods and algorithms to this aim reported in several academic papers. Some of these models including the Kidney Donor Risk Index (KDRI) are well recognized in the US and scored the key indices of kidney transplantation donated by those DBD. These indices are presented in a formal model along with certain scores.[14-16]

Scoring the features of brain death donors has been a great challenge for different institutes to specify the quality of the donated kidney. On the one hand, quite many institutes specified donor's clinical features as among the preliminary features of many scoring systems. On the other hand, the details are of an equal importance and different countries achieved different sets of features.[17-19]

In an investigation conducted in 2010, the DDS scoring system was proposed by Nyberg *et al*. and was marked by the use of SRTS data. In this study, only two key factors were prioritized in the system, including age and the last creatinine of the donor.[10] In some other research, Irish proposed the USRDS database and used it as the basis for investigating the scoring system. They incorporated both the clinical features of the donor and other features.[20,21]

The aim of the present research was to systematically review the scoring methods of different countries to determine the quality of the donated kidneys. It categorized a brain death donor's feature along with the scores. The motivation and novelty of collecting and comparing scoring systems for kidney donors are to see the experiences of different countries together if a country wants to create a dedicated scoring system.

Materials and Methods

This research was conducted as a systematic review based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses-P protocol[22] [Figure 1] up until January 2020. The studies which met the inclusion criteria were those which proposed a model or formula for setting the quality of the kidney donated by patients DBD. This evaluation was supposed to lead to the scoring, ranking, and prioritizing the donors.

Initially, the key terms are presented in Table 1 helped to extract the inclusion and exclusion criteria of articles indexed in PubMed, Science Direct, and general exploring engines. These key terms were set according to the key relevant concepts and according to the field specialists' comments based on Mesh.

Once the key terms were set as well as the inclusion and exclusion criteria, the search script [Table 2] was

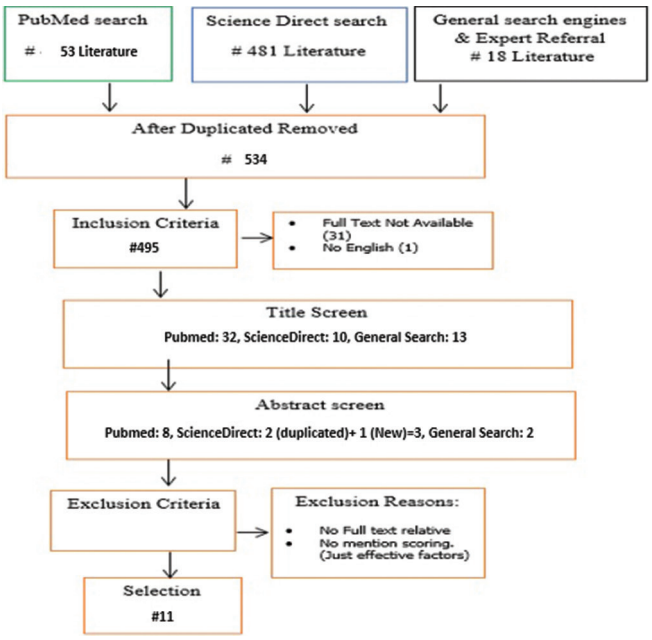

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses-P protocol

Table 1: The keywords for searching the articles which are related to the scoring systems

Concepts	Keywords	
	MeSH	Non-MeSH (articles and guidelines)
Kidney transplantation	Renal Transplantation - Renal Transplantations - Transplantations, Renal - Transplantation, Renal - Grafting, Kidney - Kidney Grafting - Transplantation, Kidney - Kidney Transplantations - Transplantations, Kidney	Graft, Kidney- Kidney Graft - Grafting, Renal - Renal Grafting - Graft, Renal - Renal Graft - Transplant, Kidney-Kidney, Transplant-Transplant, Renal-Renal, Transplant
Donor	Required Organ Donation Request - Required Request - Required Requests - Organ Donation - Organ Donations - Organ Procurement - score system - Donor score Systems - Donor Selection - Selection, Donor - Donor Screening - Transplant Donor System	Deceased Donor
Deceased (cadaver)	Determination of Death - Near-Death Experience - Brain Death - Death, Brain - Brain Dead - Brain Deads - Cadavers - Corpse - Corpses	
Priority	Priorities, Health - Health Priority - Priority, Health -	Ranking - Rank- Matching - Match - Score - Scoring

Table 2: The search script has been done by authors

PubMed	(Renal Transplantation [Title/Abstract] OR Renal Transplantations [Title/Abstract] OR ((“transplantation”[MeSH Terms] OR “transplantation”[All Fields] OR “transplantations”[All Fields]) AND Renal [Title/Abstract]) OR Transplantation, Renal [Title/Abstract] OR ((“transplantation”[Subheading] OR “transplantation” [All Fields] OR “grafting”[All Fields] OR “transplantation”[MeSH Terms] OR “grafting”[All Fields]) AND Kidney [Title/Abstract]) OR Kidney Grafting [Title/Abstract] OR transplantation, Kidney [Title/Abstract] OR Kidney Transplantations [Title/Abstract] OR ((“transplantation”[MeSH Terms] OR “transplantation” [All Fields] OR “transplantations”[All Fields]) AND Kidney [Title/Abstract]) OR ((“transplants”[MeSH Terms] OR “transplants”[All Fields] OR “graft”[All Fields]) AND Kidney [Title/Abstract]) OR Kidney Graft [Title/Abstract] OR ((“transplantation” [Subheading] OR “transplantation” [All Fields] OR “grafting” [All Fields] OR “transplantation”[MeSH Terms] OR “grafting”[All Fields]) AND Renal [Title/Abstract]) OR Renal Grafting [Title/Abstract] OR ((“transplants”[MeSH Terms] OR “transplants” [All Fields] OR “graft”[All Fields]) AND Renal [Title/Abstract]) OR Renal Graft [Title/Abstract] OR ((“transplants” [MeSH Terms] OR “transplants” [All Fields] OR “transplant” [All Fields] OR “transplantation” [MeSH Terms] OR “transplantation” [All Fields]) AND Kidney [Title/Abstract]) OR ((“kidney” [MeSH Terms] OR “kidney” [All Fields]) AND Transplant [Title/Abstract]) OR ((“transplants”[MeSH Terms] OR “transplants”[All Fields] OR “transplant”[All Fields] OR “transplantation” [MeSH Terms] OR “transplantation” [All Fields]) AND Renal [Title/Abstract]) OR (Renal [All Fields] AND Transplant [Title/Abstract]) AND (Score System [All Fields] AND Deceased Donor [Title/Abstract]) AND Graft [Title/Abstract]) OR Patient Selection [Title/Abstract] OR Patient Selections [Title/Abstract] AND Selection [Title/Abstract]) OR Predictive Factor [Title/Abstract] OR Predictive Variable [Title/Abstract] OR Prognostic [Title/Abstract]) AND (Determination of Death [Title/Abstract] OR Brain Death [Title/Abstract] OR Death, Brain [Title/Abstract] OR Brain Dead [Title/Abstract] OR ((“brain”[MeSH Terms] OR “brain”[All Fields])
Science direct	(tak (Renal Transplantation) or tak (Renal Transplantations) or tak (Transplantations, Renal) or tak (Transplantation Renal) or tak (Grafting Kidney) or tak (Kidney Grafting) or tak (transplantation Kidney) or tak (Kidney Transplantations) or tak (Transplantations Kidney) or tak (Graft Kidney) or tak (Kidney Graft) or tak (Grafting Renal) or tak (Renal Grafting) or tak (Graft Renal) or tak (Renal Graft) or tak (Transplant Kidney) or tak (Kidney Transplant) or tak (Transplant Renal) or tak (Renal Transplant) or tak (Priorities Health) or tak (Health Priority) or tak (Priority Health) or tak (Score system) or tak (Ranking) or tak (Rank) or tak (Matching) or tak (Match) or tak (Score) or tak (Scoring) or tak (Patient Selections) or tak (Selection Patient) or tak (Predictive Factor) or tak (Predictive Variable) or tak (Prognostic)) AND (tak (Determination of Death) or tak (Brain Death) or tak (Death Brain) or tak (Brain Dead) or tak (Brain Deads) or tak (Cadavers) or tak (Corpse) or tak (Corpses))

produced and the search began in the target databases. This search followed no time limitation.

The articles were analyzed by two researchers and following a problem-solving strategy, a third researcher consulted with. The articles were selected according to the inclusion criteria: (1) proposing a model or formula for determining the quality of the kidney donated by those DBD, (2) access to the full text of the article in English). The selection order of the articles followed the procedure of first examining the titles and then selecting those relevant. It went on with the perusal of the abstracts. Once the articles whose abstract was found to be relevant were spotted, the full text was read and those meetings the exclusion criteria were out. These criteria were: (1) no model or formula proposed, (2) the key factors involved in the donated kidney were mentioned, but these factors had not led to a scoring, (3) the key factors belonged only to the living donors. The general features of the articles are categorized in Table 3. Similarly, Table 4 includes the scoring systems of the donors based on the donor's manner of scoring and the relevant factors.

Moreover, the extracted models from the body of research were examined through a visit paid to formal national websites and helped to map the current conditions in the target country. The extracted models were compared and contrasted and analyzed based on the underlying factors in each and every model.

Results

The search process in the present research yielded 524 articles obtained from three databases, 506 of which were articles and 18 were guidelines. Once the recurrent articles

Table 3: Categorization of the scoring systems of kidney donors

Row	Donor factors (kidney graft function after brain death)	Year	Authors' names	Country	Model name descripted
1	Age, last donor creatinine (mg/dL)	2012	Arnau A Plata-Munoz JJ	Spain	DDS[23,24]*
2	Age, sex, diabetes, hypertension, BMI, ethnicity, creatinine	2017	Procurement O Jun, H	USA	The KDRI scoring system[25,26]*
3	Age, sex, diabetes, hypertension	2016	Koo TY,	Korea	Prediction model of RGF[27]
4	Age, height, weight, history of hypertension, history of diabetes, serum creatinine (mg/dL), hepatitis C serology, ethnicity	2015	Lee AP	USA	The KDRI and KDPI were introduced in the USA as a refined version of the ECD score[28]
5	Age, hypertension, history of diabetes mellitus, creatinine>1.5 (mg/dL)	2014	Philosophe B	Maryland	MAPI[29]
6	Cold ischemia time (hours), donor age (years), recipient BMI (kg/m^2), last donor creatinine level (μmol/L), depleting induction treatment	2014	Chapal M	France	DGFS[30]
7	Age, cerebrovascular disease, history of hypertension, creatinine clearance, number of HLA, MM	2009	Plata-Munoz JJ	U.K	The DDS system[24]
8	HBP, diabetes (D), (a) glomerular sclerosis, (b) tubular atrophy, (c) interstitial fibrosis, and (d) vascular lesion	2004	Faenza A	Italy	SOKD[31]
9	Donor age (years), history of high blood pressure, donor cr (on admission), donor cr (just before nephrectomy), average urine flow _50 (mL/h) (just before donor nephrectomy), average blood pressure _60 (mm Hg) (just before donor nephrectomy)	2017	Nakagawa Y	In the United States and Europe	ECD[32]

DDS=Deceased donor score, KDRI=Kidney donor risk index, RGF=Reduced graft function, KDPI=Kidney donor profile index, MAPI=Maryland aggregate pathology index, SOKD=Suboptimal kidney donors, ECD=Expanded criteria donor, HBP=Hypertension, HLA=Human leukocyte antigen, BMI=Body mass index, MM=Mismatches

Table 4: Comparison of the scoring systems

Row	Item	Spain UK	USA	Korea France	Maryland	Italy	Europe
	Model name	DDS	KDRI	DGF	MAPI	SOKD	ECD
1	Age	√	√	√	√	×	√
2	HLA	√	×	×	×	√	√
3	Cerebrovascular disease	√	×	×	×	√	×
4	History of hypertension	√	√	×	√	√	√
5	Creatinine clearance	√	×	√	√	×	√
6	Diabetes	×	√	×	√	√	×
7	Sex	×	√	√	×	×	×
8	BMI	×	√	√	×	×	×
9	Ethnicity		√				
10	HCV status		√				

HLA=Human leukocyte antigen, BMI=Body mass index, HCV=Hepatitis C virus, DDS=Deceased donor score, KDRI=Kidney donor risk index, DGF=Delayed graft function, MAPI=Maryland aggregate pathology index, SOKD=Suboptimal kidney donors, ECD=Expanded criteria donor

were eliminated, 11 data sources were left, 9 of which were articles and 2 belonged to grey sources. All the articles which met the inclusion criteria were from 7 different countries among which over 60% belonged to American countries. 50% of the articles had been written from 2013 onward (the earliest article was written in 2006 and the latest in 2017).

From the final data sources, 9 models and algorithms were extracted which comprised an overall 10 factors. Some of these models such as KDRI were commonly used by different countries.

All the models entailed at least 4 factors and about 90% of the models considered 4 or 5 factors to evaluate the extent to which those DBD were prepared for kidney transplantation. The foremost factor belonged to the KDRI model in the U. S. comprised of 7 factors.

More than 60% of the models included the age, history of blood pressure, and creatinine factors.

In all the scoring models, the age and history of blood pressure of the donor DBD were received the highest scores. Moreover, the impact of the human leukocyte antigen (HLA) typing factor is evident in selecting the candidates for transplantation in several models.

Table 3 presents a categorization of the scoring systems of kidney donors DBD in different countries.

In addition, to compare the extracted models, Table 4 is presented to make comparison possible between and among the models of different countries as well as their distinctive features.

The ethnicity and hepatitis C factors were only incorporated in the U. S. In a similar fashion, the body mass index (BMI) factor was exclusive to the U. S., Korea, and France. Similarly, the cerebrovascular disease factor only belonged to models of Spain, England, and Italy. Research findings are comparative statistics of various studies that have been systematically developed. Statistics of systematic research achievement tables are available.

Discussion

The quality of the body organs donated has been recognized among the key factors involved in renal functioning.[11] Thus, the presence of a scoring system for donors DBD is of a great significance. Using prognostic models does not replace doctor's decision-making. Instead, it merely affects medical decisions made. Two of these models used in Europe and U. K. are expanded criteria donor (ECD) and deceased donor score (DDS).[23,24,32]

ECD is defined based on age and three statistical risk factors: SRTR (Scientific Registry of Transplant Recipients) which stands in the history of venal blood pressure, serum creatinine (SCr) level exceeding 1.5 mg/DL, and the SCr level of 1.5 mg/dL or mortality caused by brain stroke.[28]

Moreover, the definition of ECD managed to reduce the risk of failed transplantation of a kidney from a brand death donor and shorten the waiting time of those in need of transplantation. It also reduces the risk of organ loss during the transplantation. DDS estimates the use of the donor's clinical data before the transplantation. Compared to ECD, DDS has shown to be a better means of diagnosing marginal organs and a donor's clinical data in the primary function of the transplantation and its survival.[28]

Another model which is marked by a scoring system is American in origin. This model is known as KDRI which has been introduced as the ranking index for the risk kidney DBD take and is used widely to evaluate the functioning of transplantation outcomes.[33] To evaluate high-risk donors, ECD criteria show that the age and background diseases have been the alternative risk factors for creatinine. Moreover, in KDRI, the negative coefficient of creatinine is >1.5 mg/DL which reduces the significance of creatinine as an independent factor.[34]

In the majority of these models, such factors as age, HLA typing, BMI, and the history of diabetes are highly significant.[20,23,28,34,35] Furthermore, they are significant in candidates.[36]

The age factor plays a key role in almost all scoring systems. In DDS, the older the dead donor, the higher the score gained. In this model, the maximum score for a dead donor (above 70 years of age) is 25 which is higher than any other factor listed in Table 5. However, in KDRI, the highest score would go to a dead donor above 50 years of age.[6]

Another factor recognized as highly influential in the survival rate of the transplantation is the kidney receiver's age. Older patients enjoy a lower probability of failed transplantation than the younger. In other words, the chances of successful transplantation are higher among the older groups.[24]

In the delayed graft function (DGF) scoring system, the age factor was rated as the lowest of all. Only 2 scores are assigned to a dead donor above 50 years of age, which, as compared to the other factors summarized in Table 6, represents the lowest score.[30] Similarly, the SOKDS scoring system assigned the highest score, 3, to those above 50 years of age.[37]

Another important factor is HLA, which explores the correspondence of HLA antigens. Similar in age, HLA is also rated higher corresponding to an older age. In the DDS model, according to Table 5, the maximum score is 6 which ranks second only next to age.[30]

The HLA type test in potential donors and receivers can be done through a microcytotoxicity test in which the donor's as well as the receiver's white globules are distributed in a plate well. Even when there is no fully matched case for donation in terms of HLA, the transplantation could be successful.[11] The positive points of the present study are the collection of scoring systems, which makes physicians choose the best case for kidney transplantation by comparing the existing systems, and the negative point of the article was the lack of access to manual scoring models in some countries.

KDRI and DGF models [Table 6] are the only models that have incorporated BMI in their scoring systems. Finally, the history of diabetes and hypertension are also included in some models as indicated in Table 4. The

Table 5: Deceased donor score system

Clinical data	Total
Scoring chart	
Donor age (years)	0-25
Donor history of hypertension (no/yes: years)	0-4
Donor final creatinine clearance*	0-4
Donor number of HLA mismatches	0-3
Donor cause of death=cerebrovascular disease	0-3
Total score	0-39

HLA=Human leukocyte antigen

Table 6: Delayed graft function score system

Variable	Score
Age	
<50	0
50-65	2
Primary cause of death	
Trauma	0
CAD	2
Other causes	4
History of hypertension	
No	0
<10	3
≥10	6
History of diabetes	
No	0
Yes	2
Hypertension process	
No	0
Yes	3
Vasopressor used	
No	0
Yes	2
CPR event	
No	0
Yes	3
eGFR before donation	
>60	0
40-60	3
20-40	6
Score range	0-28

eGFR=Estimated glomerular filtration rate, CPR=Cardiopulmonary resuscitation, CAD=Coronary artery disease

higher the blood pressure in these models, the higher the assigned score. Moreover, a history of diabetes enjoys a higher score than the absence of such a history.[25,26,30] It is suggested that if a country or a group of researchers want to create a new model, they must study the different models of different countries and consider their differences and create their own native model.

The limitation of this study contains the lack of comprehensive websites to sort all the scoring systems of kidney donation from deceased donors. The positive point of this study is to collect all the related scoring system in the world as a comprehensive study which can help physicians to use these systems according to their situations and positions.

Conclusions

Prognostic models are of key significance due to the existing long wait lists for kidney transplantation. As the results of the present research showed, in all models, a higher score was assigned to age and the history of hypertension. Furthermore, the impact of the HLA Typing factor in the selection of candidates for transplantation has been specified in some models. Further research can investigate the effect of these models on the survival of kidney transplantation.[38,39] One of the biggest limitations of the work has been the lack of access to the full version of the scoring systems of some countries, which has prevented the researcher from making a more detailed comparison. Another limitation of countries' indigenous experiences is that they sometimes choose different factors for scoring, for which a common clinical justification may not be conceivable.

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Conflicts of interest

There are no conflicts of interest.

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