DOI: 10.7860/JCDR/2025/74620.21304

Original Article

Microbiology Section

Prevalence of Human Leukocyte Antigen Incompatibility between Recipients of Live Relative Donor and Deceased Donor in Renal Transplantation in a Tertiary Care Centre in Southern India: A Cross-sectional Study

THERESE MARY DHASON[1], SORNARANJANI MANICKAM[2], ANANTHAKRISHNAN PARTHASARATHY[3], KALPANARAJ DORAIRAJ[4], THYAGARAJAN RAVINDER[5], SUGANTHI MANIKESI[6], MADHUMATHY AUGUSTINE[7], DEVI CHITHSABESAN[8]

ABSTRACT

Introduction: The treatment options available for End-Stage Renal Disease (ESRD) are dialysis or kidney transplantation. Renal transplantation increases the lifespan of the patient and affords a better quality of life when compared to dialysis. The demand for organs is very high compared to the availability of donors. The donors in kidney transplantation can either be a relative (live donor) or a deceased donor. The outcomes of renal transplantation depend on the Human Leukocyte Antigen (HLA) match between the donor and the recipient.

Aim: To determine the prevalence of HLA mismatch between recipients of live relative donor kidneys and deceased donor kidneys in renal transplantation.

Materials and Methods: The study was a cross-sectional observational study conducted from May 2023 to May 2024 at Government Kilpauk Medical College, Chennai, Tamil Nadu, India after obtaining approval from the Institutional Ethics Committee. Since renal transplantation has been occurring only from May 2023 onwards and the number of samples received for testing was limited, all the samples received for crossmatch testing were included in this study to find the prevalence of HLA incompatibility. HLA crossmatching was performed using the microlymphocytotoxicity test. Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 21.0. A Chi-square test was applied to determine the significance of the study results.

Results: In this study, 49 live relative donors and 49 recipients were included, along with 12 deceased donors and 42 recipients awaiting renal transplantation. Female donors predominated among live donors, with 34 (69.39%) compared to 15 (30.61%) male donors in the live donor crossmatch. In the deceased donor crossmatch, male donors were predominant, with 7 (58.33%) compared to 5 (41.67%) female donors. The compatibility between live donors and recipients was 48 (97.96%), whereas for deceased donors and recipients it was 35 (83.33%). A comparison of the positive crossmatch between the recipients of live donors and deceased donors showed statistical significance (p-value=0.01438 at 0.05). A Chi-square test was conducted to assess the statistical significance of the Complement Dependent Cytotoxicity (CDC) test crossmatch and Flow Cytometry crossmatch, which was not significant (p-value=0.289013 at 0.05).

Conclusion: Live relative donor transplantation has a better match than deceased donor transplantation. The CDC test plays a major role in HLA crossmatching in resource-constrained healthcare facilities.

Keywords: Flow cytometry, Live donor, Microlymphocytotoxicity test

INTRODUCTION

Chronic Kidney Disease (CKD) has become a major cause of global morbidity and mortality in developing countries. CKD affects more than 850 million people worldwide and is projected to become the fifth largest cause of years of life lost by 2024 [1]. The prevalence of CKD has increased to epidemic proportions, with population-based studies reporting a 4-20% prevalence of CKD in India [2].

Renal transplantation is the treatment for end-stage renal failure. Open and laparoscopic surgery are the common modes of renal transplantation. Patients with ESRD who have undergone renal transplantation have better long-term survival compared to those who remain on dialysis. They experience a survival benefit of 10 years over those who continue on dialysis. The donor can be either a living relative or a deceased (cadaveric) donor. The Transplantation of Human Organs Act, passed by the Indian Parliament in 1994, was ratified by the state legislature of Tamil Nadu in May 1995 and accepted brain death as a form of death [3].

Allograft rejection is a major complication of renal transplantation, with the rejection rate being more common in deceased donor transplantation. Allograft rejection occurs when the recipient's immune system recognises the non self antigen in the allograft. While both innate and adaptive immune systems play significant roles in rejection, T lymphocytes are the principal cells that recognise the allograft [4].

The HLA sensitisation is a major public health problem that limits access to renal transplantation for 30% of patients awaiting a kidney transplant. To reduce rejection reactions, pretransplant HLA crossmatching is performed in all cases planned for allograft renal transplantation. An increasing number of HLA mismatches has been shown to be associated with poorer graft and patient survival

following kidney transplantation. HLA mismatches remain a crucial component of deceased donor kidney allocation in most countries, including the United States and Australia. HLA typing has evolved from serological-based typing to molecular HLA typing and solid-phase anti-HLA antibody detection assays, significantly influencing both the allocation and outcome of transplanted kidneys.

The detection of Donor-Specific Anti-HLA antibodies (DSA) in recipients through various methods helps prevent rejection reactions. Crossmatching assays to establish the presence of DSA have evolved from CDC assays to exquisitely sensitive flow-cytometric and solid-phase assays. The availability of these sensitive assays has enabled clinicians to perform virtual crossmatching, which aids in accurately assessing the immunological risk of potential transplant candidates and improving the allocation of deceased donor kidneys [5].

HLA crossmatching methods include the Microlymphocytotoxicity test, flow cytometry, Enzyme-Linked Immunosorbent Assay (ELISA), and Multi-Analyte Profiling (xMAP) technology. The Microlymphocytotoxicity test is a simple examination that does not require costly equipment for HLA typing and crossmatching [6]. This CDC test requires viable lymphocytes from the donor and detects DSA when present in high titers [7].

Flow cytometry, on the other hand, does not require viable lymphocytes and can detect DSA in low titers. It is recommended to perform HLA crossmatching by flow cytometry when the viable lymphocyte yield is low for carrying out a CDC crossmatch [8]. T cell crossmatch and B cell crossmatch can be performed by flow cytometry, unlike the CDC crossmatch, in which isolating B lymphocytes is difficult. However, in resource-constrained healthcare institutions, the CDC crossmatch plays a major role in renal transplantation.

Hence, a comprehensive study was undertaken to determine the prevalence of HLA incompatibility among deceased and live relative donors in renal transplantation using the microlymphocytotoxicity test and flow cytometry. Since renal transplantation only began in May 2023 and the number of samples received for testing was limited, all samples received for the crossmatch test were included in this study to determine the prevalence of HLA incompatibility. The aim of the study was to perform the microlymphocytotoxicity test to detect mismatches among recipients of live relative donors and deceased donor renal transplantation. To perform flow cytometry crossmatch in recipients of live relative donors and deceased donor kidneys.

MATERIALS AND METHODS

This cross-sectional observational study was conducted in the Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India for one year, from May 2023 to May 2024. Institutional ethics committee approval was obtained via IEC protocol NO.983/2023 dated August 3, 2023. Written informed consent was obtained from the participants recruited for the study.

Inclusion criteria: Patients with CKD planned for renal transplantation were included in the study.

Exclusion criteria: Patients with chronic renal failure on medical treatment were excluded from the study.

In this study, 49 live relative donors and 49 recipients, as well as 12 deceased donors and 42 recipients without a relative donor awaiting renal transplantation, were recruited.

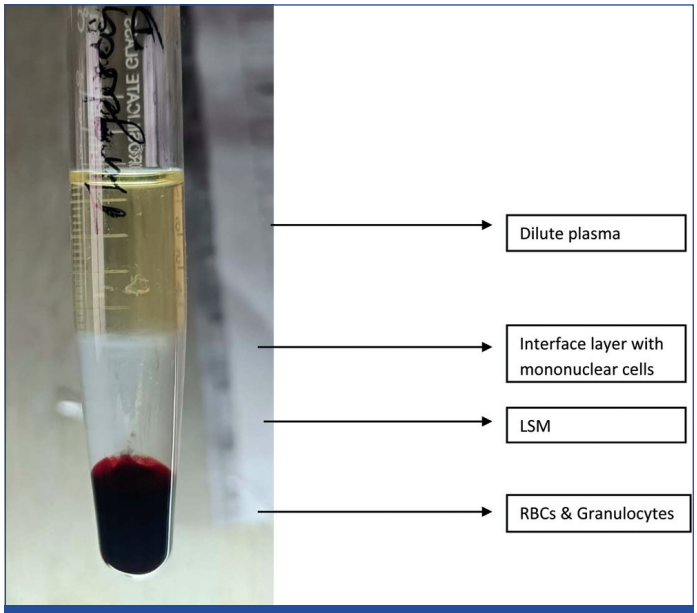
Methods

Microlymphocytotoxicity method: The subjects were advised to fast for eight hours before the sample collection. Under aseptic precautions, an Acid Citrate Dextrose (ACD) blood sample (1.5 mL of ACD with 8.5 mL of blood) and a 5 mL blood sample without anticoagulant were collected from the donor. From the recipient, a 5 mL blood sample without anticoagulant was collected. Lymphocyte isolation from the donor was performed by density gradient separation using Ficoll Isopaque {Lymphocyte Separation Medium (LSM)}. HLA crossmatching was performed using uncoated Terasaki trays by the Microlymphocytotoxicity test.

Procedure

Step 1: Lymphocyte isolation by density gradient separation.

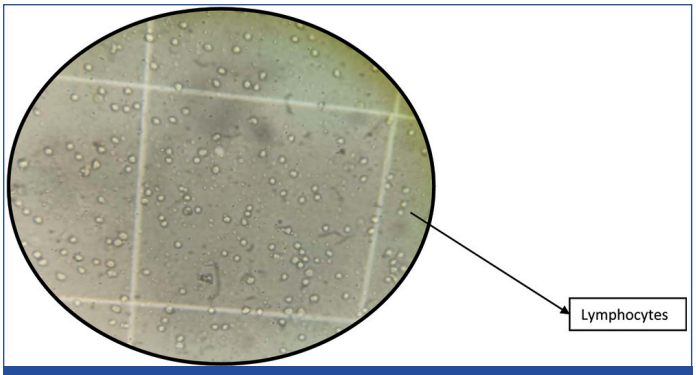
Under strict aseptic precautions, 8.5 mL of blood was collected by venipuncture of peripheral veins and added to a glass test tube containing 1.5 mL of ACD. It was mixed gently several times. In another test tube, 3 mL of phosphate-buffered saline was taken, and 3 mL of anticoagulant blood was added and mixed well. In a graduated conical centrifuge test tube, 3 mL of LSM was taken, and 5 mL of diluted blood was added slowly through the sides of the tube without mixing with LSM, then centrifuged at 2000 RPM for 30 minutes. The different layers separated after centrifugation are shown in [Table/Fig-1].



[Table/Fig-1]: Lymphocyte separation by Density gradient method. (Image from the present study).

Using a clean Pasteur pipette, the dilute plasma present in the upper layer was aspirated without disturbing the interface layer and discarded. Then, the interface layer was aspirated using a Pasteur pipette and added to another test tube containing 2 mL of Phosphate-Buffered Saline (PBS). To this, 4 mL of PBS was added, mixed well, and centrifuged at 1000 RPM for 10 minutes. The supernatant was discarded, and 4 mL of PBS was added to the sediment, which was then centrifuged at 1000 RPM for five minutes. The supernatant was discarded. The test tube was inverted to remove the remaining PBS, and then 50 µL of PBS was added to the sediment and mixed well. One drop was taken in a Pasteur pipette and loaded into a clean Neubauer WBC counting chamber. Using a light microscope, the number of viable lymphocytes in a small square at the corners of the triple-walled WBC square was counted. This is shown in [Table/Fig-2]. The optimum number of cells should be 20 to 30 per small square for performing the Microlymphocytotoxicity test.

Procedure for CDC HLA crossmatch: Terasaki uncoated trays were thawed at 20-25°C for 15 minutes. The Positive Control (PC), Negative Control (NC), donor and recipient were marked on the uncoated Terasaki plate. In each well, 1 µL of mineral oil was added. According to the markings, appropriate specimens were added. The rows on the uncoated Terasaki plate were marked as PC, NC, Donor (D) serum, and Recipient (R) serum, starting from the first row. Then, 1 µL of donor cell suspension was added to each well using a Hamilton syringe. The trays were incubated at room temperature (20-25°C) for 30 minutes. In the next step, 5 µL



[Table/Fig-2]: Lymphocytes in Neubauer chamber (Image from original study).

of rabbit complement was added to each well. The trays were then incubated at room temperature (20-25°C) for one hour. After one hour, 5 µL of 4% eosin dye was added to each well, followed by the addition of 5 µL of formal saline after five minutes. The trays were read after 15 to 30 minutes.

Validation of CDC crossmatch assay:

Positive Control (PC): Should show dead cells amounting to 90 to 100% dead cells.

Negative Control (NC): Should show viable cells amounting to 90 to 100%.

Viable lymphocytes appear small, uniformly sized, bright and refractile.

Dead lymphocytes appear larger in size, eosin-stained and non refractile.

By applying the International scoring system for histocompatibility, the reactions were scored. The scoring system is depicted in [Table/Fig-3]. The results were interpreted as a negative crossmatch when the percentage of dead cells was less than 20% and as a positive crossmatch when it was more than 20% [9].

Cell lysis %	Score	Interpretation
0-10	1	Negative
11-20	2	Probably negative
21-50	4	Weak positive
51-80	6	Positive
81-100	8	Strong positive

[Table/Fig-3]: International scoring system for histocompatibility.

Flow Cytometry Crossmatch

Procedure: Serum samples, including the positive and Negative Controls (NCs), were unfrozen and centrifuged. The cells were treated with Pronase to remove Fc receptors and/or CD20 from the cell surface in order to reduce non specific reactivity in the B cell flow cytometry crossmatch. In a glass tube measuring 6×50 mm, 200,000 to 250,000 cells were added. The cells were centrifuged to form a pellet in a tabletop centrifuge for one minute at 700×g. The supernatant was aspirated. Then, 25 µL of the appropriate serum was added to the pellet in each corresponding tube. The serum and cells were mixed thoroughly using a vortex mixer. The tubes were incubated for 30 minutes at 4°C in the refrigerator. The cells were then washed with cold wash buffer. The cells were centrifuged again to form a pellet in a tabletop centrifuge for one minute at 700×g. The supernatant was aspirated, and the wash was repeated two more times. The Positive Control (PC) was aspirated last to decrease the chance of carryover. After aspirating the PC, the tip was rinsed. Then, 20 µL of FITC anti-IgG (or IgM, if applicable) was added to each tube and incubated at 4°C in the dark for 10 minutes. After 10 minutes, 20 µL of CD3 PerCP and 20 µL of CD19-PE were added, gently vortexed and incubated at 4°C in the dark for an additional 20 minutes. The cells were then washed two times with 400 µL of cold wash buffer and centrifuged. The cell pellet was resuspended in 200 µL of cold wash buffer. While vortexing, 200 µL of cold buffer and 1% paraformaldehyde were added to each tube. Cells were analysed or held at 4°C in the dark for up to seven days. The Median Channel Fluorescence (MCF) of the NC was subtracted from all samples and the difference was recorded.

For the T cell crossmatch, interpretation was done as follows [10]:

T cells ≤30 channels=Negative

30 <T cells ≤45 channels=Probable negative

T cells ≥45 channels=Likely positive

STATISTICAL ANALYSIS

Data collected were entered into an Excel spreadsheet and statistical analysis was performed using SPSS version 21.0. Mean values and percentages were calculated. The Chi-square test was employed to determine the significance of the study results.

RESULTS

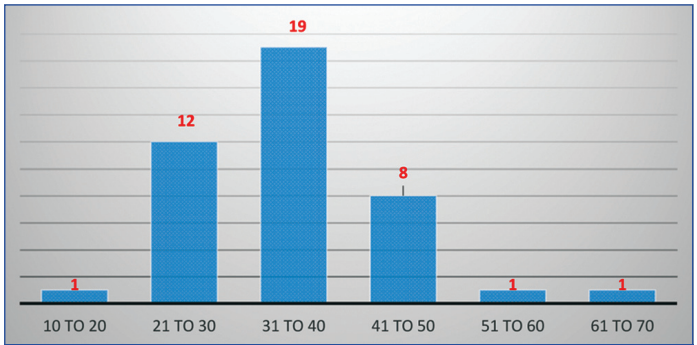
Sex distribution of live relative donor and deceased donor: The sex distribution of live relative donors and recipients was analysed. Female donors were predominant, with 34 (69.39%) compared to male donors with 15 (30.61%) in the live donor crossmatch. Additionally, among the recipients, a female preponderance of 29 (59.18%) was found when compared to male recipients at 20 (40.82%). In deceased donors, 7 (58.33%) were male donors and 5 (41.67%) were female donors. Male recipients (22, 52.38%) outnumbered female recipients (20, 47.62%). There was no statistical significance (p-value >0.050) in the sex distribution between males and females in both live and cadaver kidney transplantation.

Age distribution of donors: The age distribution of donors who were tested for HLA crossmatch in renal transplantation was analysed and is presented in [Table/Fig-4].

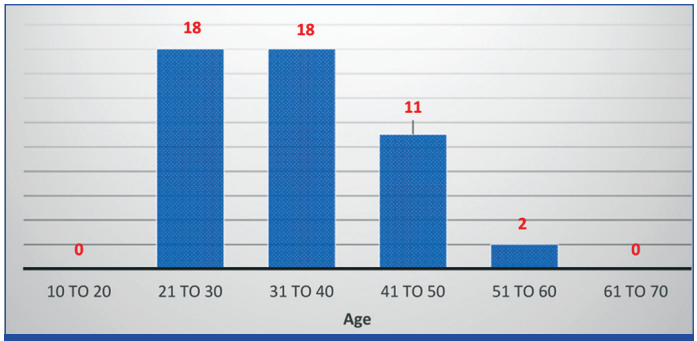
Age group (years)	n (%)
10-20	1 (1.64)
21-30	9 (14.76)
31-40	10 (16.39)
41-50	14 (22.95)
51-60	19 (31.15)
61-70	8 (13.11)

[Table/Fig-4]: Age distribution of donors tested for HLA cross match n=61.
On analysis of the age group of donors tested for HLA crossmatch in renal transplantation, it was found that a higher proportion of the donors belonged to 51 to 60 years of age

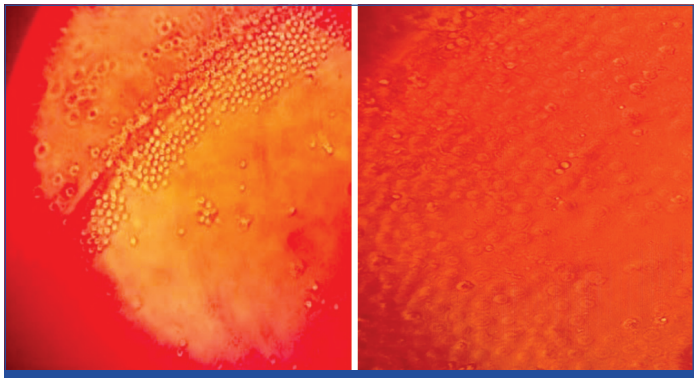
Age distribution of recipients: The age distribution of recipients tested for HLA crossmatch against deceased donors is provided in [Table/Fig-5]. The age distribution of recipients in the live donor crossmatch is depicted in [Table/Fig-6]. The morphology of viable cells in negative crossmatch and dead cells in positive crossmatch is shown in [Table/Fig-7].



[Table/Fig-5]: Age distribution of recipients tested for HLA crossmatch against deceased donor n=42.
The highest number of recipients tested for HLA cross match against deceased (cadaver) donor were of age group 31 to 40 years followed by 21 to 30 years of age



[Table/Fig-6]: Age distribution of recipients in LIVE donor crossmatch n=49.
On analysing the age group of recipients tested for HLA cross match against live donors, a higher proportion of the recipients were between 21 and 40 years



[Table/Fig-7]: Viable cells and dead cells in negative and positive crossmatch.

Negative and positive crossmatch in live relative donor (CDC): The negative and positive crossmatch results obtained by CDC in live relative donors are analysed and presented in [Table/Fig-8]. The proportion of positive crossmatch results in live relative donor renal transplantation was found to be very small compared to the negative crossmatch.

Results	n (%)
Negative crossmatch	48 (97.96)
Positive crossmatch	1 (2.04)
Total	49 (100)

[Table/Fig-8]: CDC negative crossmatch vs. positive crossmatch in live relative donor (n=49).
p-value is 0.00001* Significant at 0.05

Negative and positive crossmatch in deceased donor (CDC): The number of CDC negative and positive crossmatches found among deceased donors is tabulated in [Table/Fig-9]. The positive and negative crossmatch results between recipients of live relative donors and deceased donors were analysed and provided in [Table/Fig-10].

Results	n (%)
Negative crossmatch	35 (83.33)
Positive crossmatch	7 (16.67)
Total	42 (100)

[Table/Fig-9]: CDC negative crossmatch vs. positive crossmatch in deceased donor (n=42).
Negative cross match was more compared to positive crossmatch in deceased donor

Donor and recipient	Negative	Positive
Recipients of live relative donor n=49	48	1
Recipients of deceased donor n=42	35	7

[Table/Fig-10]: Negative vs. positive crossmatch in live donors vs. deceased donors.
p-value is 0.01438* Significant at 0.05

Comparison of negative and positive crossmatch among live relative donor and deceased donor: The comparison of positive and negative crossmatch reactions between live and cadaver renal transplantation showed significant results at the 0.05 level.

CDC crossmatch and flow cytometry crossmatch: The positive and negative crossmatch results using the CDC method and the flow cytometry method were analysed and provided in [Table/Fig-11]. There was no statistical significance between the two methods of testing used for HLA crossmatch in renal transplantation.

Methods	Negative crossmatch	Positive crossmatch
Complement dependent crossmatch n (91)	83	8
Flow cytometry n (50)	48	2

[Table/Fig-11]: CDC crossmatch vs. flow cytometry crossmatch.
p-value is 0. 289013
Not significant at 0.05

DISCUSSION

The treatment options available for ESRD are dialysis or kidney transplantation. Renal transplantation increases the lifespan of the patient and provides a better quality of life when compared to dialysis [11]. The prevalence of ESRD requiring transplantation in India is estimated to be between 151 and 232 per million population [12]. The demand for organs is significantly higher compared to the availability of donors. The donors in kidney transplantation can be either a living relative donor or a deceased donor. In the case of a deceased donor, the organ is allocated to the recipient based on the registry maintained by TRANSTAN. Once individuals are placed on the waiting list, the waiting period varies from a few days to several years. In the United States, the average waiting time is three to five years [13]. Therefore, a comprehensive study was conducted to explore various perspectives on kidney transplantation.

In this study, the proportion of female donors was higher than that of male donors in relative donor transplantation. Global observational data indicate that sex and gender disparities exist among living relative donors, with women outnumbering men [14,15]. In high-income countries such as the United States, Canada, and Australia, approximately 60% of all living kidney donors are women [16,17]. Socio-economic, biological and cognitive or emotional factors have an impact on gender disparities in live kidney donors [18,19]. However, in deceased kidney donors, a male preponderance was observed in this study. This finding aligns with a study conducted in India [20].

Among the recipients of kidneys from live relative donors and deceased donors, gender disparity was found to be negligible in present study. In contrast, according to an Indian study, there is a significant gender disparity in access to renal transplantation in India, particularly in the state of Gujarat [21]. Among the total 91 recipients ,49 (53.84%) were females and 42 (46.15%) were males. Conversely, a study by Bloembergen WE et al., indicated that males were predominant as recipients [22]. In the study by Mukherjee D et al., the proportion of females among recipients was 47.8%, while that among donors was 34.8%. In present study, among the recipients, 49.50% were female, and among the donors, 71.79% were female [23].

In this study, the predominant age group of the donors was 51-60 years. The absolute contraindication for organ donation regarding age is being less than 18 years [24]. However, in the study by Rajapurkar MM et al., the majority of the donors were between 10 and 39 years old [21].

As far as the recipients are concerned, most of them belonged to the 21-40 age group in this study. In contrast, in the study by Khoda M et al., the majority of the recipients were between 31-40 years old [24]. The outcomes of renal transplantation depend on the HLA match between the donor and recipient. The presence of preformed Donor-Specific Antibodies (DSA) in recipients can lead to rejection reactions. The recognition by Patel R and Terasaki PI

in 1969 of the association between hyperacute renal transplant rejection and recipient alloantibody to donor antigens enhanced the understanding of transplant-related reactions [25].

Hence, the microlymphocytotoxicity test, also known as the CDC test, was performed on all samples for HLA crossmatching prior to organ transplantation. In this study, the HLA mismatch between the live relative donor and recipient was 2.04%. In comparison, the HLA mismatch between deceased donor and recipient was much higher at 16.67%. This finding aligns with a study by Leeaphorn N et al., which reported that 33% of HLA mismatches occurred in deceased donors and 16% in live related donor renal transplantation [26].

Flow cytometry precisely detects the presence or absence of IgG DSA on donor lymphocytes. Compared to the CDC crossmatch, flow cytometry crossmatch is more sensitive [27]. Since different laboratories use various assays for crossmatch testing, the results can vary from one laboratory to another [28]. To compare the results of the CDC crossmatch and flow cytometry crossmatch, out of the 91 samples tested by the CDC assay, 50 samples were also tested by flow cytometry in this study. Among the 91 samples tested by CDC-XM, eight samples were detected as positive; out of the 50 samples tested by FC-XM, two samples were detected as positive. Upon analysis of the results of flow cytometry crossmatch and CDC crossmatch, no statistical significance was observed, and the results were concordant. This finding was consistent with a study conducted by Bilgen T et al., which confirmed that there are no statistically significant differences between the CDC-XM method and the FC-XM method [29]. In contrast, in the study by Rani L et al., among 79 samples, 24 were detected as positive by FC-XM, while three samples were detected as positive by the CDC-XM method [30].

Limitation(s)

The sample size in this study was small; hence, further studies with a larger sample size will have an impact on the various perspectives of renal transplantation. Due to resource constraints, flow cytometry crossmatch could not be carried out for all samples.

CONCLUSION(S)

Gender disparity was observed in kidney donors, with a female preponderance. This issue needs to be addressed with awareness programs on organ donation to encourage male donors. The mean age of the recipients was 35 years for live donors and 36 years for deceased donors, respectively. As young adults often develop ESRD due to various causes, early intervention must be initiated in patients with renal diseases. HLA mismatch is more prevalent in deceased donor transplantation; therefore, live relative donor transplantation should be encouraged. When comparing the CDC and flow cytometry methods for crossmatching, there was no significant difference between the two methods. Consequently, the microlymphocytotoxicity test plays a pivotal role in institutions where flow cytometry is not available.

Acknowledgement

Authors sincerely thank their Dean Dr. Muthuselvan MD for granting permission to conduct the study at the institution and for her relentless support and encouragement. Authors are indebted to the Director of King Institute of Preventive Medicine and Research, for approving grant for the study.

REFERENCES

[1] Raghavan V, Anandh U. Journey of a patient with CKD in India. Kidney 360. 2023;4(5):684-86.
[2] Soni KK, Kalyanasundaram M, Singh S, Shubham S, Sabde YD, Prakash A, et al. Prevalence of chronic kidney disease among severely gas-exposed survivors in Bhopal, India. Natl Med J India. 2023;36(1):05-10.
[3] Garovoy, Rheinschmidt M, Bigos M, Perkins H, Colombe B, Feduska N, et al. Flow cytometry analysis: A high technology cross-match technique facilitating transplantation. In 1983 [cited 2024 Aug 3]. Available from: https://www.semanticscholar.org/paper/Flow-cytometry-analysis%3A-A-high-technology-Garovoy-Rheinschmidt/e8e594815e1b5bc29dea94a374f54f38d208b145.
[4] Lazda VA, Pollak R, Mozes MF, Jonasson O. The relationship between flow cytometer crossmatch results and subsequent rejection episodes in cadaver renal allograft recipients. Transplantation. 1988;45(3):562-65.
[5] Lee PP, Garovoy MR. Flow cytometry crossmatching: The first 10 years. Transplant Rev. 1994;8(1):01-14.
[6] Nguyen HD, Williams RL, Wong G, Lim WH, Nguyen HD, Williams RL, et al. The evolution of HLA-matching in kidney transplantation. In: Current issues and future direction in kidney transplantation [Internet]. IntechOpen; 2013 [cited 2024 Aug 4]. Available from: https://www.intechopen.com/chapters/42879.
[7] Rodey G, Bollig B, Oldfather J, Schutte L, Flye W, Phelan D. Extra reactivities detected in flow-cytometry-positive, CDC-negative crossmatches are definable HLA specificities. Transplant Proc. 1987;19(1 Pt 1):778-79.
[8] Thistlethwaite JR, Buckingham M, Stuart JK, Gaber AO, Mayes JT, Stuart FP. T cell immunofluorescence flow cytometry cross-match results in cadaver donor renal transplantation. Transplant Proc. 1987;19(1 Pt 1):722-24.
[9] Dyer P, Middleton D. Histocompatibility testing: A practical approach. Oxford: Irl Press, Oxford University Press; 1993. (xxii+ 303 pages) ISBN 0 19 963363 0.
[10] Clinical Transplantation 1986 Los Angeles UCLA Tissue Typing Laboratory - Search [Internet]. [cited 2024 Aug 5]. Available from: https://www.bing.com/search?pglt=43&q=Clinical+Transplantation+1986+Los+Angeles+UCLA+Tissue+Typing+Laboratory&cvid=963963265dba4141af09c0512ff4aab4&gs_lcrp=EgZjaHJvbWUyBggAEEUYOdIBBzg4NWowajGoAgCwAgA&FORM=ANNTA1&PC=HCTS.
[11] MEH [Internet]. Kidney Transplant | Mount Elizabeth Hospitals. [cited 2024 Aug 8]. Available from: https://www.mountelizabeth.com.sg/conditions-treatments/transplant/kidney-transplant.
[12] Modi GK, Jha V. The incidence of end-stage renal disease in India: A population-based study. Kidney Int. 2006;70(12):2131-33.
[13] Øien CM, Reisaeter AV, Leivestad T, Pfeffer P, Fauchald P, Os I. Gender imbalance among donors in living kidney transplantation: The Norwegian experience. Nephrol Dial Transplant. 2005;20(4):783-89.
[14] Kayler LK, Rasmussen CS, Dykstra DM, Ojo AO, Port FK, Wolfe RA, et al. Gender imbalance and outcomes in living donor renal transplantation in the United States. Am J Transplant Off J Am Soc Transplant Am Soc Transpl Surg. 2003;3(4):452-58.
[15] ANZDATA - Australia and New Zealand dialysis and transplant registry - ANZDATA [Internet]. [cited 2024 Aug 6]. ANZDATA- Australia and New Zealand dialysis and transplant registry. Available from: https://www.anzdata.org.au/anzdata/.
[16] Hart A, Lentine KL, Smith JM, Miller JM, Skeans MA, Prentice M, et al. OPTN/SRTR 2019 Annual Data Report: Kidney. Am J Transplant Off J Am Soc Transplant Am Soc Transpl Surg. 2021;21(Suppl 2):21-137.
[17] Organ replacement in Canada: CORR annual statistics. CIHI [Internet]. [cited 2024 Aug 4]. Available from: https://www.cihi.ca/en/organ-replacement-in-canada-corr-annual-statistics.
[18] Gill J, Joffres Y, Rose C, Lesage J, Landsberg D, Kadatz M, et al. The change in living kidney donation in women and men in the United States (2005-2015): A population-based analysis. J Am Soc Nephrol JASN [Internet]. 2018. [cited 2024 Aug 4];29(4):1301-08. Available from: https://pubmed.ncbi.nlm.nih.gov/29519800/.
[19] Ghods AJ, Nasrollahzadeh D. Gender disparity in a live donor renal transplantation program: Assessing from cultural perspectives. Transplant Proc. 2003;35(7):2559-60.
[20] Kute VB, Chauhan S, Navadiya VV, Meshram HS, Patel HV, Engineer D, et al. India: Gender disparities in organ donation and transplantation. Transplantation. 2022;106(7):1293-97.
[21] Rajapurkar MM, John GT, Kirpalani AL, Abraham G, Agarwal SK, Almeida AF, et al. What do we know about chronic kidney disease in India: First report of the Indian CKD registry. BMC Nephrol. 2012;13(1):10.
[22] Bloembergen WE, Mauger EA, Wolfe RA, Port FK. Association of gender and access to cadaveric renal transplantation. Am J Kidney Dis Off J Natl Kidney Found. 1997;30(6):733-38.
[23] Mukherjee D, Nair RK, Sharma S, Datt B, Rao A, Prakash S. Cadaveric renal transplantation: Our experience at a tertiary care centre in India. Med J Armed Forces India. 2020;76(1):58-62.
[24] Khoda MME, Rahim MA, Shimu IJ, Islam RN, Hossain MG, Mansur MA. Immediate outcome and one-year graft survival rate after live related kidney transplantation: Experience in a tertiary care hospital of Bangladesh. Bangladesh J Med. 2021;32:39-42.
[25] Patel R, Terasaki PI. Significance of the positive crossmatch test in kidney transplantation. N Engl J Med. 1969;280(14):735-39.
[26] Leeaphorn N, Pena JRA, Thamcharoen N, Khankin EV, Pavlakis M, Cardarelli F. HLA-DQ mismatching and kidney transplant outcomes. Clin J Am Soc Nephrol CJASN. 2018;13(5):763-71.
[27] Tinckam KJ. Basic histocompatibility testing methods. In: Chandraker A, Sayegh MH, Singh AK, editors. Boston, MA: Springer US; 2012 [cited 2024 Aug 4]. pp. 21-42. Available from: https://link.springer.com/10.1007/978-1-4614-0008-0_2.
[28] Scornik JC, Bray RA, Pollack MS, Cook DJ, Marrari M, Duquesnoy R, et al. Multicenter evaluation of the flow cytometry T-cell crossmatch: Results from the American Society of Histocompatibility and Immunogenetics-College of American Pathologists proficiency testing program. Transplantation. 1997;63(10):1440-45.

[29] Bilgen T, Canbakan M, Şahin G, Titiz Mİ. Comparison of cytotoxic flow cytometric cross match with complement dependent lymphocytotoxicity and flow cytometric cross match in renal transplant patients. Transplant Proc. 2019;51(4):1021-23.

[30] Rani L, Singh H, Saikia B, Aggarwal R, Kumar Y, Kumar M, et al. Novel flow cytometry-based method for detection of anti-HLA complement activating donor-specific antibodies in renal transplant recipients and its comparison with other conventional detection methods. Transplant Proc. 2023;55(1):134-39.

PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Microbiology, Bharat Medical College, Chennai, Tamil Nadu, India.
2. Assistant Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.
3. Assistant Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.
4. Assistant Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.
5. Professor and Head, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.
6. Associate Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.
7. Assistant Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.
8. Assistant Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Ananthakrishnan Parthasarathy,
Assistant Professor, Department of Microbiology, Government Kilpauk Medical College, Chennai-600010, Tamil Nadu, India.
E-mail: drananthu@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 20, 2024
- Manual Googling: Mar 07, 2025
- iThenticate Software: Apr 05, 2025 (4%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: Grant from The Tamil Nadu State Research Committee Rs. 30,000/-
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 19, 2024**
Date of Peer Review: **Dec 27, 2024**
Date of Acceptance: **Apr 08, 2025**
Date of Publishing: **Aug 01, 2025**