Inducing All Our ‘Low-Risk’ Transplant Candidates: Shall We Or Shall We Not?

Keywords: Induction; Rejection; Thymoglobulin; Basiliximab; Low immunological risk

Abstract
Acute rejection episode (ARE) in an allograft recipient has a negative impact on graft survival, and therefore, preventing ARE is of paramount importance. Induction by antibody preparations is one such strategy that has been proven effective in preventing AREs, but there are certain ambiguities in their use particularly in low immunological risk transplants. Anti-interleukin-2 receptor therapy had gained widespread usage in this group of patients because it does not incur additional risks of infectious and malignant sequelae associated with thymoglobulin. However, recent literature found it to be no better than “no induction” strategy. Thymoglobulin, being frequently used in North America for induction even in low risk group, has been used in variable doses across transplant centers. The minimal possible dose of Thymoglobulin that avoids majority of adverse effects while retaining an optimal treatment benefit has not been clearly defined. Moreover, the effects of induction by antibody preparations on long term graft function and survival remain variable. Majority of the published work on induction immunosuppression is retrospective and is difficult to interpret because of a wide spectrum of maintenance immunosuppressive regimen in vogue. This review of literature has been performed to analyse published literature to assess the efficacy and appropriateness of induction agents in “low risk” transplants. We suggest that “low-risk patients receiving triple-drug immunosuppression (calcineurin inhibitors, an anti-proliferative agent and steroids) do not need ‘routine’ induction by antibody preparations.

Abbreviations
ARE: Acute Rejection Episodes; ATG: Anti-Thymocyte Globulin; SRTR: Scientific Registry of Transplant Recipients; OPTN: Organ Procurement and Transplantation Network; DGF: Delayed Graft Function; ILBS: Institute of Liver and Biliary Sciences; CMV: Cytomegalovirus; BSX: Basiliximab; IL-2RA: IL-2 Receptor Antagonists; CsA: Cyclosporine; MPA: Mycophenolic Acid; MMF: Mycophenolate Mofetil

Introduction
Renal transplant is undoubtedly the most physiological treatment option for patients with end-stage renal disease. However, the success of transplant is not without cost in terms of morbidity such as infections, metabolic derangements and malignancies. It is desirable to strike a fine balance between the maximal benefits and least side effects of immunosuppressive drugs. The rationalized use of these drugs is based on immunological risks that is essential to stratify for each patient to prevent post-transplant infective complications, which may be a state of over-immunosuppression on one hand manifesting with repeated and possibly life threatening opportunistic infections, and under-immunosuppression on the other hand presenting as graft-threatening acute rejection episodes (ARE). Immunosuppressive agents used in transplantation are classified as induction, maintenance or anti-rejection rescue therapies. Induction agents are intense agents that are used to suppress immune system prophylactically at the time of transplantation. These are highly potent agents, not surprisingly, cannot be used in long term. Agents used for maintenance therapy are less potent than induction agents. In simple terms, side effects of immunosuppression are directly proportional to potency. Rescue therapy is more or less similar to induction when it comes to potency and side effects except that it is used to treat a proven or suspected ARE.

Induction agents are used in the immediate peri-operative period to ensure maximum immune suppression immediately post-transplant when the risk of acute ‘allograft-decimating’ immunological events is at its highest. It is not mandatory to use induction in all the situations, however. They form an integral part of immune-suppression protocols in certain clinical situations like [1]:

1. In sensitized individuals (patients with prior history of transplant, transfusions, or multiple pregnancies),
2. Patients in whom late introduction of calcineurin inhibitors (CNI) is desirable such as extended criteria donor organs,
3. As a part of steroid-minimization or withdrawal regimens, and
4. In “high risk individuals” based on risk stratification.

The process of stratifying of immunological risk of a patient into low, intermediate or high risk category (Table 1) is based on histocompatibility testing, antibody screening and donor lymphocyte crossmatch in order to enable rationalization of induction therapy.

On one end of the spectrum are “high-risk candidates”, in whom the role of induction therapy cannot be underscored enough in

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preventing ARE and, thereby, improving short and long allograft outcome. These agents play a vital role in preventing both clinical and “subclinical” AREs in high-risk individual [2]. Subclinical AREs have been the prime focus of interest in high-risk individuals in recent times, as it could be an important risk factor for chronic allograft nephropathy and graft loss in these patients [3]. On the other end of spectrum, the use of induction can be termed as overkill in the “low risk candidates”. As per SRTR/OPTN 2010 annual data report, close to 83% of renal transplants done in United States use antibody preparations for induction [4].

In this article, the authors discuss various induction agents and primarily focusing on their role in “low” risk transplant candidates.

**Classification of induction agents**

Induction agents broadly fall into one of the following three categories:

1. Polyclonal antibody preparations
2. Monoclonal antibodies (MAbs), and
3. Fusion proteins (engineered glycoprotein receptor-antibody hybrids).

The induction agents in current use are biological agents, collectively they are also known as ‘biologics’. Another way of classifying them is into ‘depleting’ antibodies and ‘non-depleting’ antibodies (Table 2).

**Depleting agents** act by depleting the target cells (T cells/B cells or both). These agents were primarily described for use in rescue conditions like steroid-resistant acute cellular rejections or severe vascular rejections. However, currently they are being increasingly utilized for induction especially in “high” risk recipients.

**Non-depleting agents** are the primary agents used for induction, they are of no use as rescue agents.

Figure 1 describes the 3-signal model of T-cell activation and mechanism of action of commonly used induction agents.

**Polyclonal Antibody Preparations**

As the name suggests, these preparations act on multiple targets, both lymphocyte and non-lymphocyte cell types. Though, their main function is lymphocyte depletion but their cross-reactivity with other hematopoietic cell types results in side-effects like anemia, thrombocytopenia and neutropenia. These side effects frequently become reasons for their dose limitations and, at times, discontinuation also. The available agents in this category are:

- a. Anti-lymphocyte serum
- b. Anti-lymphocyte globulin
- c. Anti-thymocyte globulin (ATG)
  a. Rabbit-origin
  b. Equine (horse)-origin

**Role of polyclonal antibodies in pre-cyclosporine era**

In 1960s and 70s, steroids and azathioprine were the mainstay of immunosuppressive therapy in renal transplantation. This regimen was associated with unacceptably high ARE acute and graft loss. Polyclonal antibody preparations used to be given for 2-3 weeks in the immediate post-transplant period, to reinforce the effect of steroids and azathioprine. The end result was a delay in the onset of acute rejection but the strategy did not improve long-term survival [5-7].

**Role of polyclonal antibodies in cyclosporine era**

Cyclosporine was introduced for use in renal transplant in 1978 that led to a decline in the use of polyclonal preparations for
induction, for the fear of increased risk of infective and malignant complications [8,9].

Role of polyclonal antibodies in the present era of tacrolimus-based triple immunosuppression

Tacrolimus received US-FDA approval for use in kidney transplantation in 1997 i.e. three years after its use started in liver transplant. Since then, tacrolimus-based triple immunosuppression regimen (tacrolimus, mycophenolate and steroids) has become standard of care for maintenance immunosuppression. In an estimate, by 2009, close to 85% of renal recipients are discharged on tacrolimus-based triple immunosuppression

Authors Dose used No. of patients Conclusion

Agha et al. [18] 3 mg/kg intra-operatively and 1.5 mg/kg daily for 2 days 40 Thymoglobulin administered for 3 days affords comparable benefit to a 7-day course (1.5 mg/kg for 7 days, beginning intra-operatively)

Gurck-Turner et al. [19] Group1: 7.5 mg/kg LBW Group2: Higher doses Group 1: 33 Group 2: 63 They recommend not to use > 5 doses (1.5 mg/kg) for induction in high-risk group.

Hardinger et al. [20] Group1: 1.5 mg/kg x 4 days Group2: 2 mg/kg x 3 days 59 patients in each group Shorter, more intense dosing of rATG is safe and effective. The 3-day dose strategy resulted in a clinically shorter length of stay and may result in cost savings.

Laftavi et al. [21] 3-5 mg/kg total dose Deceased donor: 124 Living donor: 64 Low-dose rATG (3-5 mg/kg total dose) is safe and efficacious in low-risk kidney transplant recipients.

Wong et al. [22] Group A: 1 mg/kg x 3 days Group B: 1.5 mg/kg x 3 days Group A: 7 Group B: 9 Short course (3-day) induction therapy with either 1.0 or 1.5 mg/kg/day of rATG appears to be practical, safe and efficacious.

Klem et al. [23] Group 1: 1.5 mg/kg x 3 doses Group 2: 1.5 mg/kg x 4 doses Group 1: 39 Group 2: 44 3- or 4-dose course of rATG (1.5 mg/kg/dose) provides excellent protection against AREs even in increased risk patients. 3-day dose is associated with short hospital stay and cost savings.

Stevens et al. [24] Single dose group: 6 mg/kg Single dose group: 1.5 mg/kg x 4 doses Single dose: 76 Multiple dose: 76 Single dose rATG induction is at least equal in safety to conventional, divided dose regimen with improved early graft function.

In another similar multi-centric French study [12], which compared ATG induction with no induction in recipients with tacrolimus-based immunosuppression, it was concluded that ATG induction was associated with significantly lower risk of AREs (15.2%, as compared to 30.4% in non-induction group, p=0.001), but the therapy increased incidences of infections particularly CMV infection.

Now, the important point of discussion is whether this additional risk of infective morbidity is worth taking or not! The answer is probably "no" in low-risk candidates but in high-risk candidates it is worthwhile. A number of authors have demonstrated the superiority of ATG induction in patients who receive grafts from extended criteria donors or patients who are at high risk of rejection like re-transplants and patients with DGF [13,14].

A favorable effect of ATG was found on early mechanisms of ischemia-reperfusion injury (IRI) in a primate model [15]. It was discovered that ATG, by virtue of its properties of T-cell depletion and causing functional impairment of non-depleted circulating lymphocytes, reduce leukocyte adherence to the antigen-presenting endothelial cells. As a result, the allo-recognition events cannot take place in the post-transplant period of reperfusion and, thereby, immunological onslaught on allograft is blunted.

Another important indication for induction with polyclonal agents, in modern era, is patient in whom CNIs need to be avoided. CNI-free regimen is particularly desired in kidneys obtained from expanded-criteria donors, as these kidneys are relatively more prone to CNI-mediated vasocostriction in the immediate post-transplant period and nephrotoxicity with chronic use. Furian and colleagues have described a CNI-free protocol for marginal kidneys (dual kidney grafts from elderly donors) [16]. The protocol included induction with ATG, and maintenance therapy with sirolimus, steroids and mycophenolate mofetil. They have reported excellent results with lower incidence of DGF and better renal functions in this group.

**Availability in India**

The most commonly available and used agent is anti-thymocyte

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**Table 3**: Different dosing regimens depending on the profile of patients.

| Authors          | Dose used                                      | No. of patients | Conclusion                               |
|------------------|------------------------------------------------|-----------------|------------------------------------------|
| Agha et al. [18] | 3 mg/kg intra-operatively and 1.5 mg/kg daily | 40              | Thymoglobulin administered for 3 days affords comparable benefit to a 7-day course (1.5 mg/kg for 7 days, beginning intra-operatively) |
| Gurck-Turner et al. [19] | Group1: 7.5 mg/kg LBW Group2: Higher doses | 33, 63          | They recommend not to use > 5 doses (1.5 mg/kg) for induction in high-risk group. |
| Hardinger et al. [20] | Group1: 1.5 mg/kg x 4 days Group2: 2 mg/kg x 3 days | 59 patients in each group | Shorter, more intense dosing of rATG is safe and effective. The 3-day dose strategy resulted in a clinically shorter length of stay and may result in cost savings. |
| Laftavi et al. [21] | 3-5 mg/kg total dose Deceased donor: 124 Living donor: 64 | | Low-dose rATG (3-5 mg/kg total dose) is safe and efficacious in low-risk kidney transplant recipients. |
| Wong et al. [22] | Group A: 1 mg/kg x 3 days Group B: 1.5 mg/kg x 3 days | 7, 9            | Short course (3-day) induction therapy with either 1.0 or 1.5 mg/kg/day of rATG appears to be practical, safe and efficacious. |
| Klem et al. [23] | Group 1: 1.5 mg/kg x 3 doses Group 2: 1.5 mg/kg x 4 doses | 39, 44          | 3- or 4-dose course of rATG (1.5 mg/kg/dose) provides excellent protection against AREs even in increased risk patients. 3-day dose is associated with short hospital stay and cost savings. |
| Stevens et al. [24] | Single dose group: 6 mg/kg Single dose group: 1.5 mg/kg x 4 doses | 76, 76          | Single dose rATG induction is at least equal in safety to conventional, divided dose regimen with improved early graft function. |

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**Table 4**: Percentages of side effects associated with rATG.

| Side-effect | Percentage |
|-------------|------------|
| Fever       | 63%        |
| Chills      | 57%        |
| Headache    | 40%        |
| Nausea      | 37%        |
| Diarrhea    | 37%        |
| Malaise     | 13%        |
| Dizziness   | 9%         |
| Pain        | 46%        |
globein (ATG). In India, rabbit-origin ATG (rATG, Genzyme-Sanoft) labeled as Thymoglobulin is in use. It is available as 25 mg vial. This preparation is extracted and purified from the serum of thymic tissue-immunized rabbits.

Dosing schedule for induction

Thymoglobulin does not have US-FDA approval for use as induction agent in kidney transplant. Induction therapy remains an off-label indication of rATG. Still, it is the most commonly used induction agent worldwide. According to one estimate, almost 60% of recipients receive Thymoglobulin induction in US alone [17].

The drug has dose dependent T-cell depletion and side-effect profile. Authors worldwide [18-24], depending on the profile of patients, have used different dosing regimens (Table 3), for e.g. lower doses for low immunological risk and elderly patients. An ideal dose would be one with maximal benefit and least side effects, and is yet to be ascertained.

One clear inference from Table 3 is that there is no agreed upon ATG dose for induction. The authors have their own dosing regimens depending on their experience (i.e. ‘impression based medicine’), but one question that should be asked before selecting a particular dose is what is the lowest optimal dose that confers the most balanced therapeutic benefit? Kho et al. have made an attempt to shed some light on this by evaluating the effect of different doses of rATG on T cells, B cells and NK cells [25]. They had following conclusions from their study:

1. The ultra-low total dose of 1.5mg/kg of r-ATG results in depletion of peripheral T and NK cells for at least one week.
2. A total dose of 3 mg/kg rTAG results in significantly lower T cells for one month, however at one-year the T cell count recovers to baseline values.
3. The T cell depleting effect of a total dose of 6 mg/kg of rATG lasts for almost one year.
4. The effect on B cell remains variable depending on the batch-to-batch variability in the presence of B cell specific antibodies.

The inferences made from their study may be used as guiding principles on the dose of rATG as induction agent depending on the risk involved.

Adverse effects of ATG

The most common acute adversities due to ATG are related to either bone marrow suppression or transient cytokine release [26]. The effects due to cytokine release include serum sickness, chills, fever, rash and urticaria. As many as 20% of patients experience chills and fever, which usually respond to hydrocortisone, paracetamol and anti-histaminics. Table 4 summarizes the percentages of side effects associated with rATG.

Bone marrow suppression in the form of neutropenia, thrombocytopenia or both is seen in as many as 30% patients receiving ATG. Marrow suppression frequently becomes the reason of ATG dose adjustments or even discontinuation. For example, doses may be halved or administered at less frequent intervals if the platelet count drops to 50,000-75,000 platelets/mm³ or the white blood cell count drops to 2,000-3,000 cells/mm³. Discontinuation of the drug should be considered if these values drop below 50,000 platelets/mm³ or to < 2,000 white blood cells/mm³ [27].

Life-threatening anaphylaxis, pulmonary edema, refractory hypotension/hypertension are infrequent. Rash typically occurs late in the treatment, usually towards the end of schedule. It is self-limiting and responds to symptomatic treatment. Primary viral infections caused by cytomegalovirus, herpes simplex, epstein-barr virus and varicella are common associations with ATG use. Other dose-related haematological complications include anemia, thrombocytopenia and neutropenia.

De novo cancers particularly post-transplant lymphoproliferative disorders (PTLD) has been described to occur more frequently with ATG use. The European and American registries differ on this aspect of ATG. The European [28] registry shows an increased occurrence of PTLD with thymoglobulin, though American [29] registry does not show any difference. The probable reason for this difference is different cohorts in two registries: while European registry included cohorts before 2000s treated with higher doses, the American cohorts were after 2000 and received low-dose ATG.

A 2015 update by Hertig and Zuckermann on rATG and risk of PTLD in solid organ transplantation summarizes that it is difficult to interpret the data due to retrospective nature of the studies, however, one message is clear “the lower the dose, the lower the risk” [30].

Monoclonal Antibodies (MAbs)

Monoclonal antibodies are described based on the targeted cell surface proteins they act upon and these surface proteins are classified according to the CD nomenclature.

| MAbs           | Origin              | Target protein |
|----------------|---------------------|----------------|
| Muromonab (OKT3)   | Murine              | Anti-CD3       |
| Daclizumab     | Humanized           | Anti-CD25 IgG1 |
| Basiliximab    | Chimeric mouse-human| Anti-CD25 IgG1 |
| Alemtuzumab    | Humanized           | Anti-CD52      |
| Rituximab      | Chimeric            | Anti-CD20      |

Table 5: Classification of monoclonal antibodies based on the CD nomenclature.

Figure 3: Mechanism of action of anti-CD25 therapies.
Dosing schedule

They can also be classified based on the method for deriving them for e.g. murine, chimeric or humanized (Table 5).

**Rituximab**

Rituximab is a chimeric MAB specific for CD20. It is commonly used as a component of induction regimen in transplants across blood group barrier (ABO-incompatible) or across positive cross match, after antibody removal [31-33].

**Basiliximab**

CD25 was the first molecule to be targeted successfully with humanized monoclonal antibody. The figure 2 shows the mechanism of action of anti-CD25 therapies. Basiliximab is a chimeric mouse-human anti-CD 25 IgG1.

The main advantages of IL-2 receptor antagonist over rATG are:

1. These agents have highly favorable safety profile [33].
2. Therapy is not associated with cytokine release syndrome or serum sickness.
3. No increase in infectious complications or wound healing issues has been reported in clinical studies.
4. PTLD risk is more or less similar to no induction agent used [34].
5. These agents have fixed dose, body-weight independent schedule so ease of administration.

The disadvantages over rATG are as follows:

1. These agents have only a modest efficacy and cannot be used as rescue agents.
2. IL-2 receptor blocker induction is not that strong that it would allow CNI mono-therapy or CNI withdrawal/avoidance [35].

**Daclizumab**

Daclizumab is humanized anti-CD25 IgG1. It was commercially available for use till 2009, after that it was withdrawn from market.

**Alemtuzumab**

Alemtuzumab, commonly known as Campath, is a humanized anti-CD52 IgG1. CD52 is present on virtually all B cells and T cells, as well as macrophages, NK cells, and some granulocytes. When the alemtuzumab antibody binds to CD52, it triggers an antibody-dependent lysis of these cells. The depletion of lymphocytes is so marked that it takes several months or even up to one year after administration for a patient’s immune system to be fully reconstituted. It is marketed for use in the treatment of B-cell chronic lymphocytic leukemia, but has been widely used off-label as an induction agent in renal transplantation [37,38]. The usual dose is 30 mg subcutaneously to be given intra-operatively before reperfusion and another on day 1 postoperatively. The adverse reactions are mainly due to its depletional effects on all the 3 cell lines, resulting in neutropenia (70%), thrombocytopenia (52%) and anemia (47%). Others include nausea, vomiting, diarrhea, headache and dizziness. The clinical efficacy and safety of its use has been evaluated in randomized controlled trials. Analphylactoid reaction is potentially lethal (one such instance in Liverpool) if Campath is given intra-venously. In patients who are older than 60 years, only one dose is given (Liverpool protocol). Giancio et al. randomized 90 patients into rATG, alemtuzumab and daclizumab groups, with 30 patients in each one [39]. At the end of one year, there was no difference in the rates of biopsy proven ARES, patient and graft survival and infectious complications. Small number of subjects in each group is possibly the reason why there was no statistical difference in 2 groups.

**Fusion Proteins (Engineered Glycoprotein Receptor-Antibody Hybrids)**

**Belatacept**

It is a fusion protein composed of the Fc fragment of human IgG1 linked to the extracellular domain of cytotoxic T-lymphocyte-associated antigen 4 (CTLA-4). The drug selectively inhibits T-cell activation through costimulation blockade. Belatacept was approved by the USFDA in 2011, on the basis, in part, of 3-year data from two phase 3 studies: Belatacept Evaluation of Nephroprotection and Efficacy as First-line Immunosuppression Trial (BENEFIT) and BENEFIT-Extended Criteria Donors (BENEFIT-EXT). A less-intensive belatacept regimen is approved for use only in patients who are positive for Epstein-Barr virus (EBV), given the increased risk of post-transplantation lymphoproliferative disorder, predominantly involving the central nervous system, in EBV-seronegative patients. Patients in the belatacept trial were not prospectively stratified according to EBV status when the study started, since no safety signal was identified on the basis of EBV-negative serostatus. The decision to restrict belatacept for use only in EBV-positive patients was based on the findings of the phase 3 trials.

A recently published report [40] summarizes the final efficacy and safety results up to 7 years (84 months) after transplantation in the intention-to-treat population of BENEFIT. The study had three arms:

- a more-intensive belatacept arm,
- a less-intensive belatacept arm and
cyclosporine arm. The study reported a 43% reduction in the risk of death or graft loss for both the more-intensive and the less-intensive belatacept regimens as compared with the cyclosporine regimen. Both the belatacept arms had significantly higher mean estimated glomerular filtration rate (eGFR) than cyclosporine group 7 years after transplantation.

**Role of induction strategies in low-risk candidates**

A transplant clinician has three possible induction strategies in low-risk recipients:

a. No Induction
b. Induction with rATG
c. Basiliximab induction

Kidney Disease Improving Global Outcomes (KDIGO) proposed guidelines for induction in kidney transplant patients in 2009. The recommendations were largely based on randomized controlled trials that compared IL-2RA with ATG and no induction. They recommended that induction with biological agent should be a routine part of the initial immunosuppressive regimen (grade 1B) and IL-2RA is the agent of choice (grade 1B), with ATG kept reserved for high immunological risk patients (grade 2B). These trials were later summarized by Cochrane Collaborative group in 2010 [41]. A detailed analysis of this database reveals that the maintenance immunosuppression regimens used by these authors have been supplanted, at present, by tacrolimus and mycophenolic acid based triple regimens. Cyclosporine and azathioprine have largely been superseded by tacrolimus and MPA respectively because of reports of lower rejection rates with later combination [42-44]. With this tacrolimus based triple regimen, the current ARE episodes have already declined to 10-15%, from approximately 40-50% in cyclosporine based regimens used in 1990s [42,44,45]. How much further reduction in AREs is expected by “inducing” all low risk candidates is the question one should ask before deciding the immunosuppression protocol.

**rATG vs. no induction**

Two randomized trials [11,12] which particularly looked at this, clearly demonstrated the superiority of rATG induction therapy in lowering the incidence of early AREs and delaying the introduction of CNIs. This, however, was associated with significantly high risk of reversible bicytopenia (low platelets and leucocytes) and CMV infection. Despite significantly lowering the incidence of AREs, there seemed to be no significant impact on one-year patient or graft survival.

Another subset of “low-risk” patients in whom rATG can be beneficial are ones in whom early-steroid withdrawal is desirable. This is to reduce the morbidity associated with chronic steroid use; diabetes, weight gain to name a few. A number of authors have shown that induction with rATG allows early (in the first three months) and safe steroid withdrawals [46-50]. A lower or similar AREs was evident in all trials in rATG treated patients, but with better metabolic profile.

**Basiliximab vs. no induction**

Gavela et al. retrospectively analyzed 55 low-risk recipients, who either received basiliximab induction (n=21) or no induction (n=33), in the setting of tacrolimus-based maintenance immunosuppression [50]. They did not find any benefit of basiliximab in the study cohort and their observations made them conclude that routine administration of basiliximab cannot be justified in young low immunological risk transplant candidates undergoing tacrolimus-based immunosuppression. Hellemans and colleagues recently questioned the role of induction in standard-risk candidates receiving triple immunosuppression, as the studies [51,52-55] have suggested that absolute risk reduction for AREs conferred by addition of these agents is mere 1-4%, that too without any graft and patient survival advantage. Three of these authors [52-54] retrospectively analyzed U.S. registry data, while Lim et al. analyzed the Australia and New Zealand Dialysis and Transplant registry (ANZDATA) [55]. These authors opined basiliximab induction to be unnecessary in standard-risk population receiving triple immunosuppression. However, basiliximab induction is inferior to Thymoglobulin in the high-risk settings: high number of HLA mismatches, younger recipient age, older donor age, black ethnicity (in the United states), panel reactive antibodies > 0%, presence of donor-specific antibody, delayed onset of graft function and cold ischemia time > 24 hours [55].

Recently published work of Tanriover et al. which studied the patients from OPTN registry, who received living donor transplant from 2000 to 2012 and maintained on tacrolimus and mycophenolate at discharge [52]. It compared the effectiveness of IL-2RA to other induction agents in 36,153 patients. The study concluded that compared with no-induction therapy, IL-2-RA induction was not associated with better outcomes when tacrolimus based triple drug immunosuppression was used in living renal transplant recipients.

rATG appears to be an acceptable and possibly the preferred induction alternative for IL-2-RA in steroid-avoidance protocols. The major strengths of the study are:

a. Large study population (n=36153),
b. Standardization of baseline immunosuppression, study period (2000-2012), which is the modern era of maintenance immunosuppression, and
c. The use of propensity score methodology to address the selection bias that is almost certainly present as transplant programs determine the appropriateness of induction therapy for their programs or an individual patient. This statistical approach has not been previously used when addressing this topic and is superior to previous meta-analyses and retrospective analyses that have attempted to compare induction agents.

**rATG induction vs. basiliximab induction**

Laftavi et al. published 8-year follow-up of their low risk cohorts induced either by low dose ATG (3-5 mg/kg total) or basiliximab [21]. They classified their retrospective cohorts into four groups:

Group 1: Deceased donor transplant recipients induced with basiliximab (n=40)

Group 2: Deceased donor transplant recipients induced with low-dose rATG (n=124)
At present, a phase IV open label randomized multicentre prospective study [59] to compare ATG in parallel with a control group treated by basiliximab is under way. The study was initiated at the Nantes University hospital in July 2014. The data will be collected till April 2018, and results are likely to be published by 2019. The aim is to determine whether a short course of ATG can decrease the incidence of DGF in comparison with basiliximab in kidney transplant recipients with low immunological risk but high DGF risk. The main expected benefits of this study are:

(i) The reduction of unjustified ATG over-prescriptions associated with serious adverse events,

(ii) The reduction of chance losses related to ATG under-prescription,

(iii) The decrease in the incidence of DGF, and

(iv) The reduction in hospitalization duration and number of post-transplantation dialysis sessions.

Until this ongoing trial throws some light on the rationalization of induction agents in low-risk candidates, each center should have its own induction protocol based on published literature which should take into account the cost-implications and risk-benefit ratio.

**Conclusions**

Low-risk patients, receiving triple immunosuppression (CNI, anti-proliferative agent and steroids) do not need ‘routine’ induction by antibody preparations. The patients in whom late initiation of CNI or early withdrawal of steroids is required such as those transplanted with kidney from extended criteria organ donors, either Campath or rATG induction is safe and efficacious. Basiliximab induction has no proven advantage over “no induction” strategy in low immunological risk candidates. It just adds to the cost and, therefore, its routine use is not justified in this scenario.

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