Considerations for Improved Technique Survival Following Insertion of a Peritoneal Dialysis Catheter

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ABSTRACT **Background:** Peritoneal dialysis (PD) is a treatment option for patients with end-stage renal disease (ESRD) and cardiorenal syndrome (CRS).

Objectives: To evaluate the outcome of this patient population.

Methods: A retrospective study was conducted of patients who underwent an open or laparoscopic insertion of a PD catheter at our institution between 2009 and 2017. Data included demographics, peri-operative parameters, and long-term outcome. Patient and technique survival curves are presented, including subgroup analysis by method of catheter insertion and techniques for infection prevention.

Results: The study population included 95 men and 42 women, aged 65.7 ± 12.4 years. Mean follow-up was 34.6 ± 27.3 months. Open insertion was performed in 113 cases, while 24 underwent laparoscopic insertion. There was no difference in technique survival between these groups (P = 0.943). Removal of the catheter was required in 66% of patients. Median technique survival was 12.1 months. Two-year technique survival was 37% and 5-year technique survival was 12%. The leading cause for catheter removal was infection (69%). Application of measures for prevention of infections were significantly associated with prolonged technique survival (P = 0.001). Technique survival after 2 years was 38% with the application of a single measure and 57% with the application of two measures (P = 0.001). CRS patients (n=24) had a significantly lower overall survival rate (2-year survival 20% vs. 74%, P = 0.001).

Conclusions: The method of catheter insertion has no effect on technique survival. Prevention of infections is the most significant factor for improving the technique survival rates.

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KEY WORDS: cardiorenal syndrome (CRS), infection prevention, laparoscopy, peritoneal dialysis, technique survival

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Chronic kidney failure is a substantial burden on the Israeli health system and is the fifth leading cause of death in Israel [1]. The number of patients requiring renal replacement therapy (RRT) is increasing each year in Israel, as in other countries [1,2]. The impact of performing maintenance dialysis on a patient's lifestyle is heavy and persistent [3] and evidence comparing the outcome of hemodialysis (HD) and peritoneal dialysis (PD) are diverse. Treatment must therefore be tailored to the patients' abilities, co-morbidities, wishes, and support system [4].

Our PD unit, which is located in a district general hospital, treats and manages 10% of patients requiring RRT in our region. This ratio of PD/HD patients is comparable with other RRT centers in Israel [1]. All of the patients treated in our PD unit perform home dialysis. The choice between automated PD and continuous ambulatory PD is multifactorial and depends on clinical characteristics as well as patient preference.

The main indication for PD is end-stage renal disease (ESRD). Recent studies have suggested that PD is beneficial in fluid status control for patients with refractory heart failure [5]. Therefore, cardiorenal syndrome (CRS) has become another indication for PD insertion.

Insertion of the PD catheter is performed in an open or laparoscopic technique [6]. Operational technique is determined first by patient factors. Severe co-morbidities may contraindicate general anesthesia and laparoscopy. Previous abdominal surgeries or the need for a combined surgery (e.g., PD catheter insertion and hernioplasty) make laparoscopy more favorable. Second, as laparoscopy always necessitates general anesthesia, availability of operating rooms and anesthesiologists is also a factor.

Treatment success in PD patients is influenced by many aspects including patient factor and PD center level [7-9]. Complications of PD are mostly infectious, such as peritonitis and tunnel infection, but also mechanical complications such as obstruction and migration can occur [10,11]. Resolution of these complications often requires catheter removal or replacement and are the major reason for conversion from PD to HD [12,13]. In recent years efforts have been made to minimize infectious complications. Preventive measures include systemic prophylactic antibiotics prior to PD catheter insertion, daily application of topical antibiotics to the catheter exit site, and a detailed training program [14,15]. In our PD unit two interventions were implemented in a stepwise fashion, beginning in January 2015 [16].

In this study we evaluated the factors that have an impact on technique survival time, including insertion technique and infection prevention.

Our results may assist surgeons and nephrologists who are treating patients undergoing PD catheter insertion.

PATIENTS AND METHODS

Medical records of the patients who underwent PD catheter insertion and were treated in our institution between the years 2009 and 2017 were reviewed. Only patients who had a PD catheter inserted for the first time were included. Demographic data, medical history, indication for PD, date and type of procedure, type of anesthesia used, and operative time were recorded. Catheter-related complications were classified as early (30 days post operation) and late. Long-term follow-up included time to catheter removal and its cause as well as overall survival.

A coiled tip double cuffed catheter was used for all procedures.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This retrospective study was based on medical records alone; therefore, informed consent was not a requirement of the institutional research committee. Approval number: 0093-16-MMC.

OPEN TECHNIQUE

The open technique included 1 gram of IV cefamezine given prophylactically within an hour of the first incision. For local anesthesia, 1% lidocain was used. A 2 cm paramedian incision 2 cm below the umbilicus was made. The anterior fascia was opened, rectus muscle fibers were retracted, and the posterior fascia and peritoneum were opened with a small incision. The catheter was inserted over a guide wire toward the small pelvis and the guide wire was retracted. The peritoneum was closed around the catheter with a purse string suture of vicryl 3/0, keeping the adhesive cuff above the peritoneum and below the anterior fascia. The anterior fascia was then closed with a running suture of vicryl 0. Next, the catheter was tunneled in the subcutaneous tissue laterally, with the second adhesive cuff inside the tunnel. The subcutaneous tissue was closed with interrupted 3/0 vicryl, and the skin was closed with clips.

LAPAROSCOPIC TECHNIQUE

Under general anesthesia in supine position and after 1 gram IV cefamezine for prophylaxis, a 5 mm incision was made above the umbilicus. A Verres needle was inserted into the peritoneal cavity and the abdomen was insufflated with CO2 to a pressure of 15 mm/Hg. A 5 mm trocar was next inserted and a 5 mm camera was used to visualize the entry zone. Another 5 mm trocar was inserted through the rectus muscle distal and lateral to the umbilicus and a third 5 mm opposite to the second trocar. The abdominal cavity was checked for hernias and adhesions. The catheter was then inserted through the trocar in the opposite side and pulled out with the trocar on its planned exit site. The deep cuff was located just above the peritoneum and the catheter was tunneled in the subcutaneous tissue laterally. The tip of the catheter was located in the small pelvis and fixed to the pelvic plica with a laparoscopic suture. The trocars were removed and the skin was closed with clips.

TWO PERIODS IN WHICH INFECTION PREVENTIVE TECHNIQUES WERE IMPLEMENTED

Instruction (January 2015–February 2016)

Assessment of the training process by an infection control nurse and correction of faults was implemented. In addition patient retraining was conducted every 3 months, which occurred after each peritonitis episode and after a period of prolonged hospitalization (> 2 weeks). Retraining in all circumstances was uniformly conducted by a dedicated PD nurse and consisted of the following: observance of a dialysis exchange as regularly performed by the person responsible (either the patient, appointed caregiver, or family member), correction of any inaccuracies, and repeated observance of the procedure on a consecutive visit.

Instruction and exit site care protocol (March 2016–December 2017)

The letter was supplemented by strict adherence to exit site care, including twice weekly postoperative dressing changes performed by the dialysis unit nurse, daily application of topical gentamycin or mupirocin ointment to the exit site, and screening for nasal *Staphylococcus aureus* colonization at the time of catheter implantation. If a positive result for *S. aureus* was found, eradication was initiated with nasal mupirocin, as previously recommended (March 2016–December 2017).

Patients received home dialysis with routine check-ups and at the PD unit.

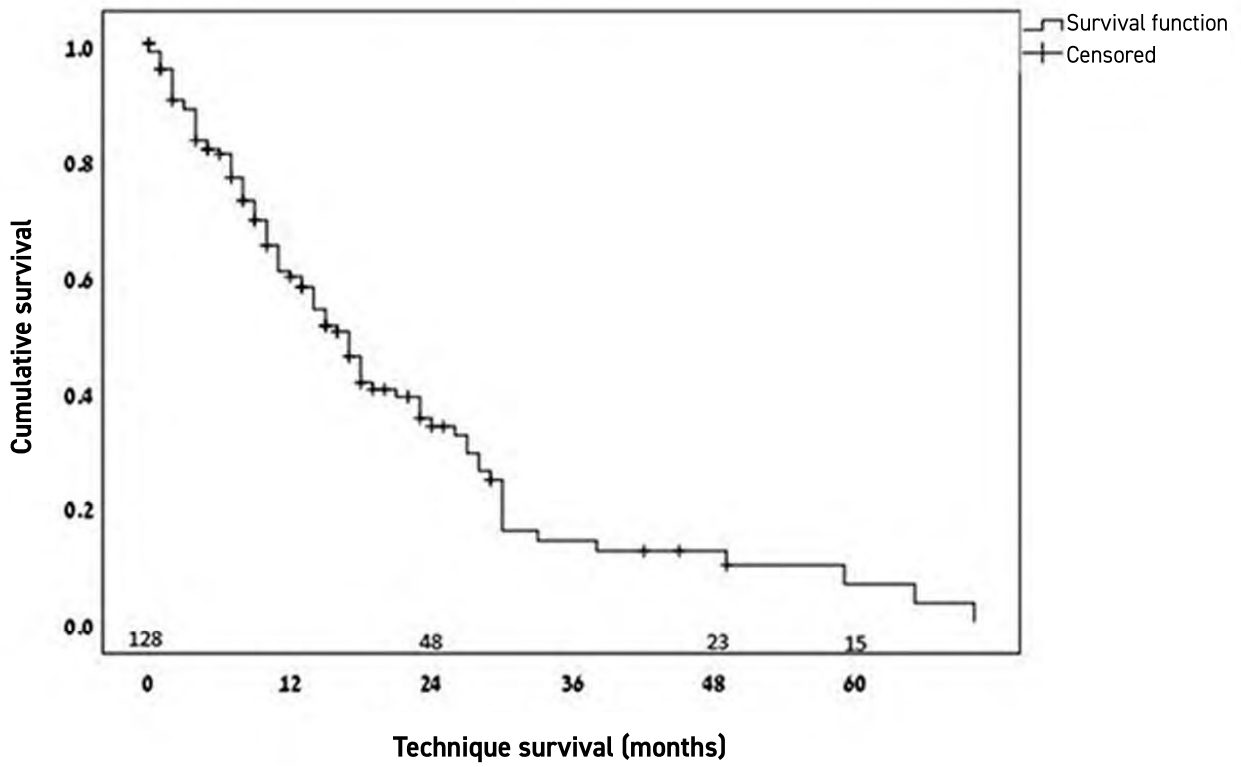
Statistical analysis was performed using the Chi-square, *t*-test, and the Mann-Whitney non-parametric tests. *P* values of less than 0.05 were considered statistically significant.

The Kaplan-Meier log rank method was used to estimate 5-year overall survival and time to catheter removal. A *P* value of < 0.05 was considered significant. Kaplan-Meier curves for catheter removal did not include patients who died of unrelated causes.

RESULTS

The study population included 95 men and 42 women, aged 65.7 ± 12.4 years. Mean follow-up time was 34.6 ± 27.3 months. Open insertion was performed in 113 patients, 10 of them under general anesthesia as insertion of the PD catheter was combined with hernioplasty and laparoscopy was not available. Laparoscopic insertion was performed in 24 patients, five combined with hernioplasty. Mean operation time was 41.1 ± 17.2 minutes for the open technique and 41.6 ± 22.3 minutes for the laparoscopic technique. Patients in the laparoscopic group had higher weight than those in the open approach group (91.8 ± 23.3 kg vs. 78.8 ± 78.5 ± 15 kg, $P = 0.021$).

Figure 1. Overall technique survival: A Kaplan-Meier curve for technique survival for the entire study population. Two-year technique survival was 37% and 5-year technique survival was 12%



Catheter removal was performed in 66% of patients (n=90) during the study period: 69% of these due to infection, 10% due to under-dialysis, 9% at their own request, 2% due to new onset hernia, and 1% due to catheter obstruction. Kidney transplantation was performed in nine patients (approximately 10% of catheter removals). As these cases were not regarded as a failure of the PD catheter, these patients were not included in the Kaplan-Meier survival curves.

Median time for catheter removal was 12.1 months (average 15.3 ± 13 months) as presented in Figure 1 (overall technique survival). Two-year technique survival was 37% and five-year technique survival was 12%. Subgroup analysis showed no difference in technique survival between patients who underwent open insertion and those who underwent laparoscopic insertion, $P = 0.943$ [Figure 2, catheter technique by type of surgery].

Peritonitis and tunnel infections were the leading cause of catheter removal. In this study, 9 patients (6.5%) had a catheter related infection in the short-term period, whereas 69 (50.3%) had an infection in the long-term period. The leading infectious agent was *Pseudomonas aeruginosa* (30%), followed by *S. aureus* (25%), coagulase negative *staphylococci* (17%), and *enterococcus* (6%).

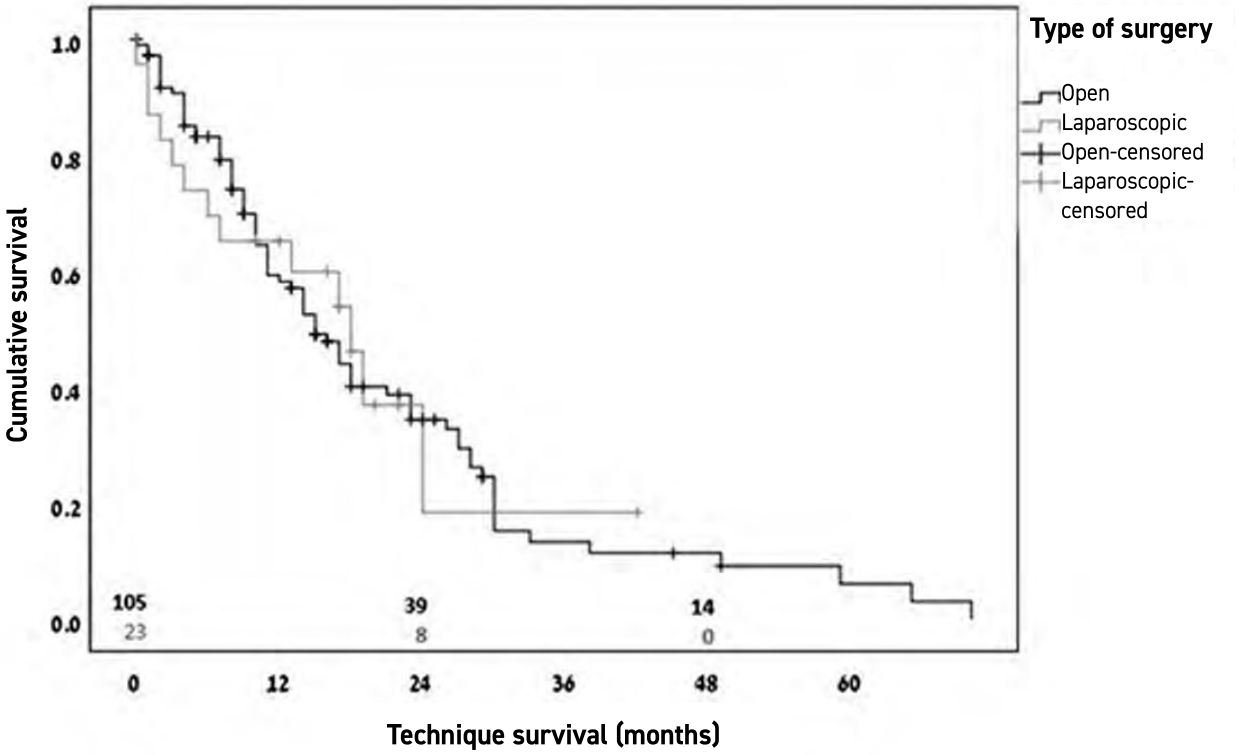
The catheter infection prevention measures were initiated in January 2015 and March 2016. The use of these measures was translated into a longer duration of technique survival. Technique survival after 2 years was 38% with the application of a single measure and 57% with the application of two measures, $P = 0.001$ [Figure 3, technique survival by period of infection preventive measure].

ESRD was the indication for PD in 113 patients, versus 24 who were treated for CRS. Patients in the CRS group had a significantly higher mortality rate (100% vs. 37.8% during follow-up, $P < 0.0001$), not attributed to age differences between the groups (CRS 69.7 ± 10.7; ESRD 65 ± 12.6, $P = 0.085$).

DISCUSSION

In most centers, PD catheter insertion is a service provided by the surgical department to the PD unit. Hence, this population of patients is not an integral part of the surgical department and is less familiar with the surgical teams. The aim of our study was to evaluate the outcome of patients undergoing a PD catheter insertion with a reference to the surgical technique used, the indication, and the postoperative infection preventive efforts. We believe that sur-

Figure 2. Catheter survival by type of surgery: Kaplan-Meier curves for technique survival divided into two groups; laparoscopic insertion and open insertion. The figure shows that there was no difference between the groups



geons performing these procedures should be familiar with them and that this knowledge will assist them when consulting patients before and after PD catheter insertions.

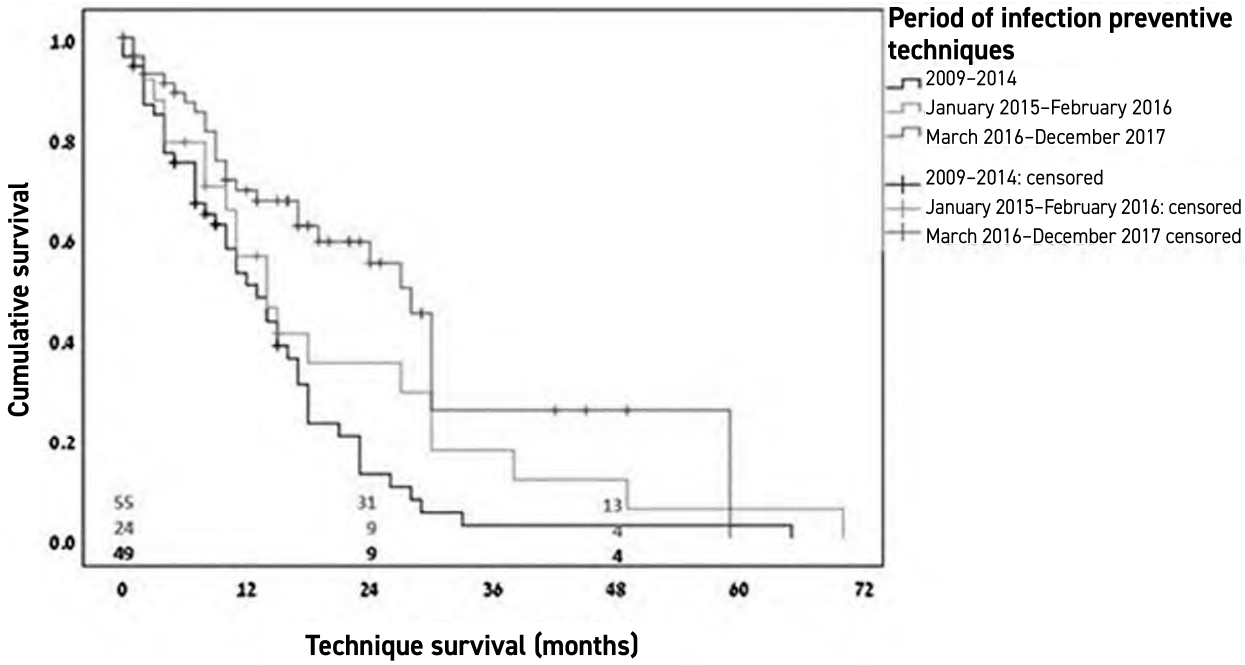
This relatively small cohort demonstrated that laparoscopy is not superior to open catheter insertion in terms of complications and technique survival. Other published reports support our results [6,17,18]. It is our preference to use laparoscopy since it enables direct visualization and fixation of the catheter and provides better pain control during the procedure itself. It is also reasonable to assume that patients with a history of abdominal surgery would benefit from the laparoscopic approach due to the possibility of adhesions. However, it is not surprising that there was no difference between the laparoscopic and open approaches in terms of outcome, since catheter obstructions, which theoretically can be prevented by locating the catheter tip under vision, are not a significant factor causing catheter removal.

It could be argued that laparoscopy has the advantage of less postoperative pain. Due to the retrospective nature of this study, we could not obtain an accurate assessment of postoperative pain but it is reasonable to assume that the difference between the approaches would not besubstantial as the incision in the open approach is relatively small. As mentioned earlier, under general anesthesia there is better pain control during the procedure itself. This advantage is more noticeable in patients with a thick abdominal wall where achieving proper local anesthesia of the peritoneum may be challenging. Therefore, patient habitus is another factor to consider when choosing the surgical approach. This finding also explains why the mean weight of patients in the laparoscopy group was higher than that of the patients in the open, local anesthesia group.

The infectious agents profile in this study included Gram positive cocci affecting 38% of patients, followed by *P. aeruginosa* affecting 30% of patients, which correlates with previous reports [19].

We found low rates of overall technique survival. Previous reports also demonstrated high catheter removal rates. In one report, 25% of PD patients transferred to HD, 70% of them within the first 2 years of starting PD [20]. Infections are the most common cause of catheter removal and infection preventive measures, as those that were implemented in our PD unit, significantly lower infection rates [16]. In subgroup analysis by infection prevention measure periods, reduction of infectious events directly translated into increased technique survival. This emphasizes the importance of continuous catheter care beyond the immediate postoperative period. Close follow-up treatment, patient education, and patient awareness to infectious complications proved to be highly effective.

Figure 3. Technique survival by period of infection preventive measure: Kaplan-Meier for technique survival divided by three periods, according to infection preventive protocols. The figure shows that technique survival correlates positively with the number of infection preventive measures



Progress has been made in developing interventions that substantially reduce the risk of PD-related peritonitis and some single center reports from recent years show improvement in technique survival [21]. In addition, new techniques such as fluoroscopic catheter insertion showed no inferiority to laparoscopy in outcome [22]. We believe that the choice of the surgical technique should integrate patient factors, physician expertise, and availability of staff and resources; however. implementation of a well-planned infection prevention program has the strongest effect on technique survival.

Long-term survival was significantly lower in the CRS group. Patients in this group had advanced heart failure and chronic kidney disease. PD was inserted as a salvage treatment for relief of refractory congestion rather than solute clearance. Recent reports have shown a benefit in hospitalizations and quality of life with the use of PD in these patients; however, impact on survival remains debatable [23,24]. High mortality in this group correlates with reports on how co-morbidities affect PD catheter survival and reports of overall survival of patients with refractory congestive heart failure [25].

CONCLUSIONS

Our recommendations for improved technique survival are as follows:

- Initiate with a laparoscopic insertion, especially in patients with central obesity, with prior abdominal surgeries, and who required a combined procedure
- Extend catheter care from the proper surgical technique and short-term postoperative management to long-term surveillance and repeating patient education
- Apply these recommendations to all patients even though they have a weaker effect on CRS patients in whom PD catheters are used as a palliative technique and in which high mortality rates are related to the primary illness

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Capsule

How to hold down COVID-19 transmission

Early in 2020, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) transmission was curbed in many countries by imposing combinations of non-pharmaceutical interventions. Sufficient data on transmission have now accumulated to discern the effectiveness of individual interventions. **Brauner** and colleagues amassed and curated data from 41 countries as input to a model to identify the individual non-pharmaceutical interventions that were the most effective at curtailing transmission during the early pandemic. Limiting gatherings to fewer than 10 people, closing high-exposure businesses, and closing schools and universities were each more effective than stay-at-home orders, which were of modest effect in slowing transmission.

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Capsule

γδ T cells suppress Plasmodium falciparum blood-stage infection by direct killing and phagocytosis

Activated Vγ9Vδ2 (γδ2) T lymphocytes that sense parasite-produced phosphoantigens are expanded in *Plasmodium falciparum*-infected patients. Although previous studies suggested that γδ2 T cells help control erythrocytic malaria, whether γδ2 T cells recognize infected red blood cells (iRBCs) was uncertain. **Junqueira** and associates showed that iRBCs stained for the phosphoantigen sensor butyrophilin 3A1 (BTN3A1). γδ2 T cells formed immune synapses and lysed iRBCs in a contact, phosphoantigen, BTN3A1 and degranulation-dependent manner, killing intracellular parasites. Granulysin released into the synapse lysed iRBCs and delivered death-inducing granzymes to the parasite. All intra-erythrocytic parasites were susceptible, but schizonts were most sensitive. A second protective γδ2 T cell mechanism was identified. In the presence of patient serum, γδ2 T cells phagocytosed and degraded opsonized iRBCs in a CD16-dependent manner, decreasing parasite multiplication. Thus, γδ2 T cells have two ways to control blood-stage malaria-γδ T cell antigen receptor (TCR)-mediated degranulation and phagocytosis of antibody-coated iRBCs.

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