

Single-Fraction Total Body Irradiation for Non-Myeloablative Treatment of Sickle Cell Disease

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INTRODUCTION

Total body irradiation (TBI) is a well-established conditioning regimen delivered prior to **hematopoietic stem transplant (HSCT)** for treatment of leukemia cancers.

Most radiotherapy centres prescribe 1000-1200 cGy in 200 cGy/fx, BID.

Global Disease Burden:

Sickle Cell Disease (SCD) globally affects > 7.7 million people, with 80% prevalence rates in sub-Saharan Africa, India and Central-Asia [1].

SCD is a hereditary, non-malignant disease that causes formation of abnormal red blood cells. SCD patients can suffer from **painful symptoms** and **severe lifelong complications**, with **limited treatment options** available.

Globally, **there has been a 20-year 14% increase in SCD rates** [2]. A **single TBI dose of 200-400 cGy** has been shown to be effective as part of HSCT non-myeloablative curative treatment for SCD [3].

This study reports on a national referral hospital's experience in treating a large SCD patient cohort with TBI.

METHODS AND MATERIALS

A **single-institution IRB approved retrospective study** was conducted at a Saudi Arabian national referral hospital. Records of **SCD patients who received low-dose TBI** between **2015-2024** were reviewed.

Data extraction included: patient demographics, disease information, TBI treatment parameters, radiation-induced toxicities, and in-vivo measurement results.

All patients were treated using an extended SSD bilateral technique, 10 MV, beam spoiler, and rice bags to provide a uniform dose distribution. Testicular shielding was used for male patients.

Figure 1 shows the patient treatment steps included in this study.

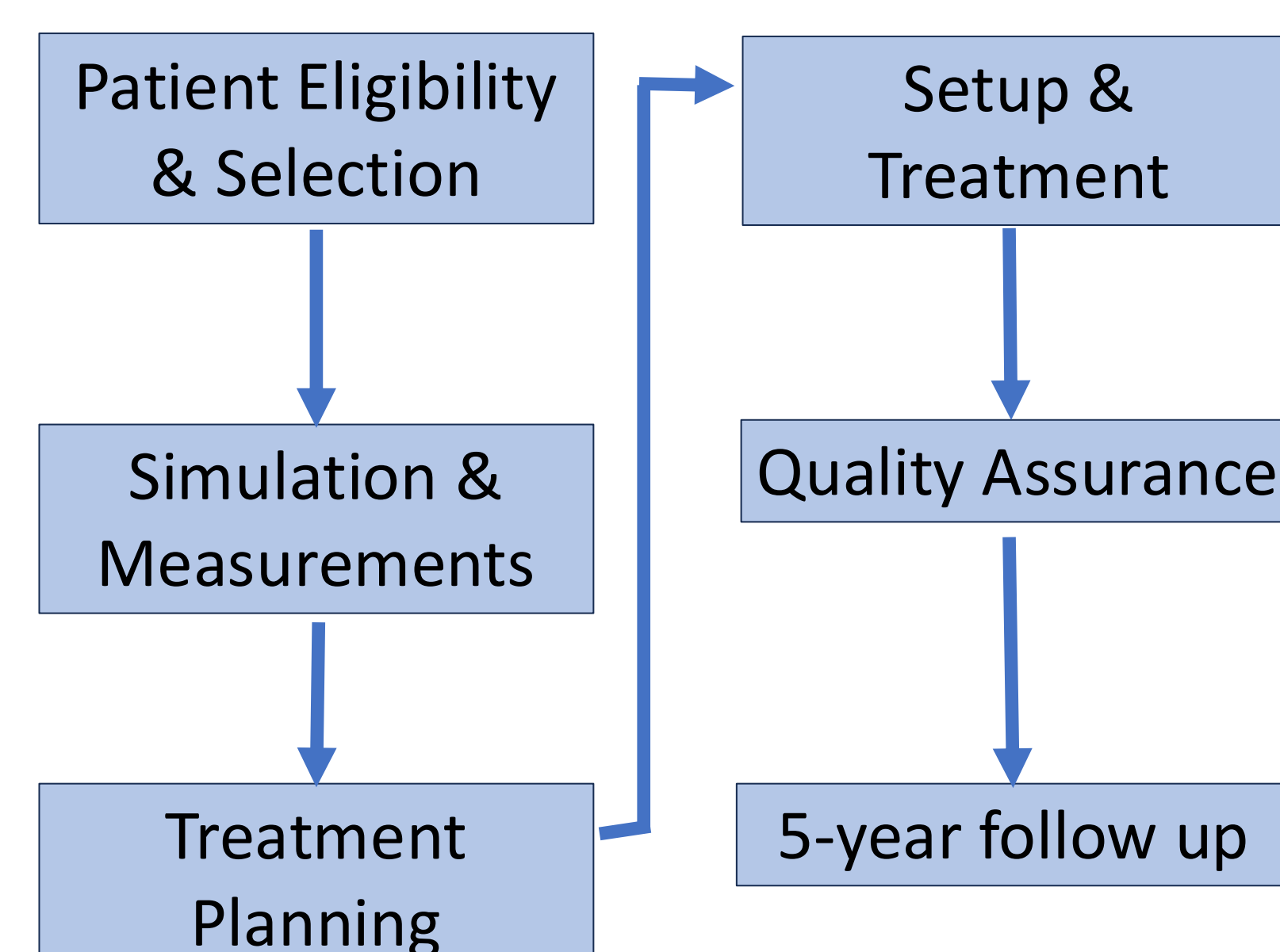


Figure 1. Treatment steps included in this study.

RESULTS & DISCUSSION

I. PATIENT DEMOGRAPHICS

Total: 275 patients diagnosed with SCD
Sex: 55% Male, 45% Female
Age: 25.4 ± 7.8 years old
Patient maximum separation range: 18-44 cm
Nationality: 99.3% Saudi

Patient distribution by **city of origin** are shown in Figure 2. Due to hereditary predisposition to SCD disease in Jizan, most patients were from that region.

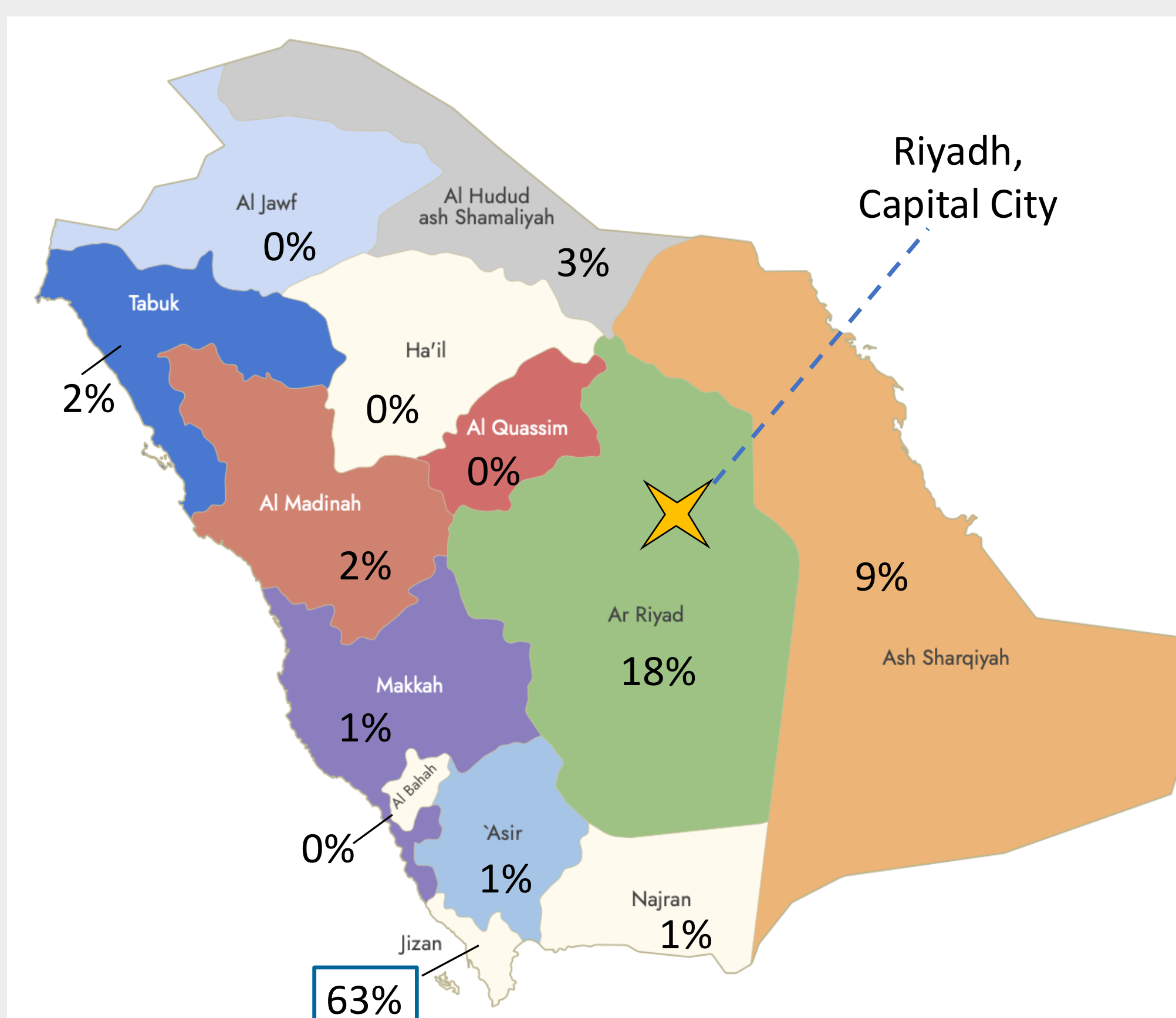


Figure 2. Map of Saudi Arabia showing the TBI patients' province of origin (total n=275). Most were from Jizan.

II. TREATMENT PLANNING

- Delivery:** 10 MV, 400 MU/min, 5-10 cGy/min
- Setup:** Bilateral extended SSD (450 cm), field size= 40 x 40 cm², collimator angle= 45° with rice bags and custom in-house built treatment table (**Figure 3**).
- Patient Separation Measurement & Planning Time:** 15– 25 min
- Calculation:** Excel-based calculation to determine MU's depending on the patient's maximum separation (**Figure 4**). For each plan, 10-12 fields were used to keep the MU's/field < 1000.
- Shielding:** testicular shielding was used in 96.7% male patients. Lung shielding was not used.
- Prescription dose:** 200 cGy/1 fx: 13.0 % & 300 cGy/1 fx: 87.0%

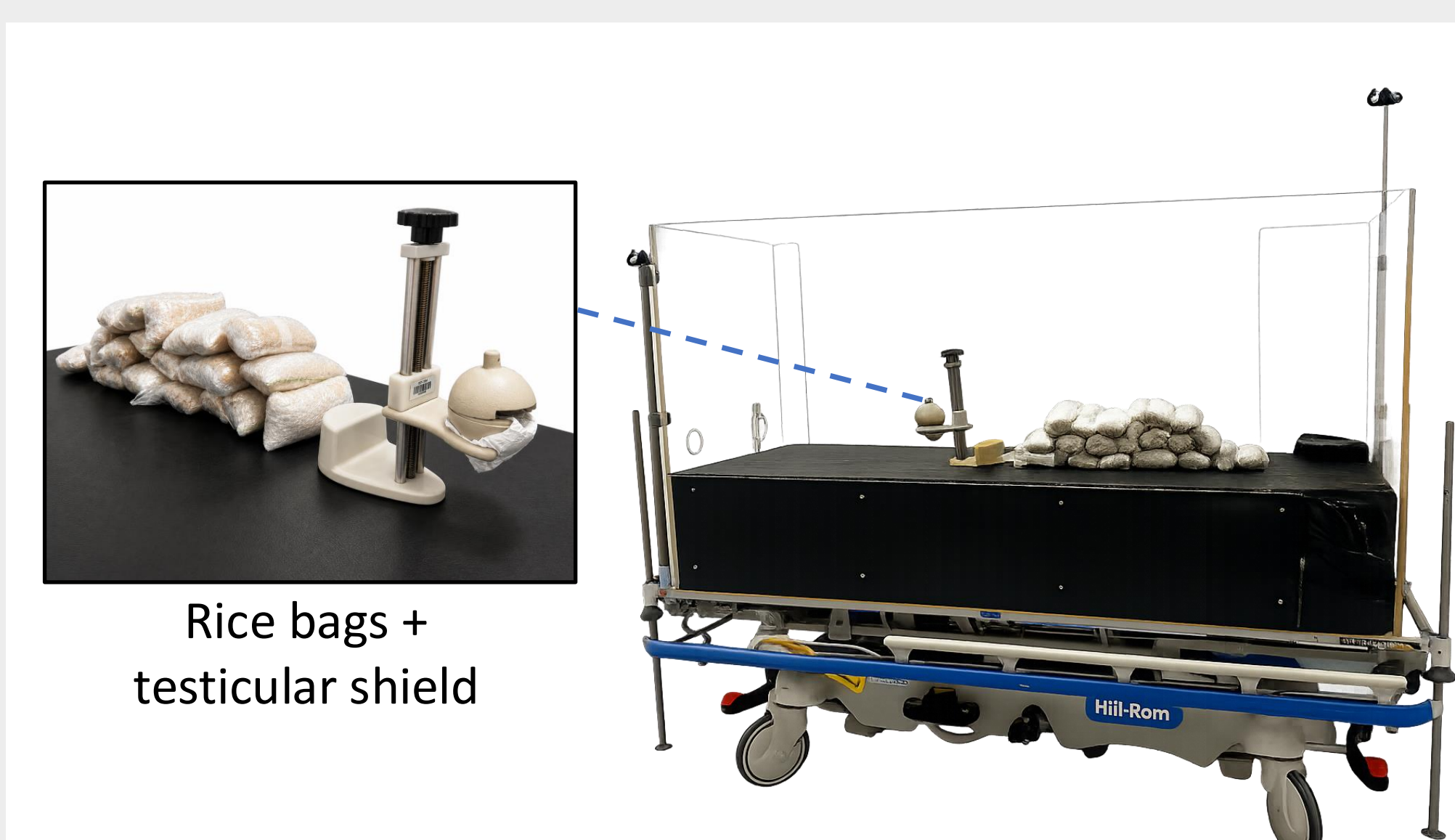


Figure 3. The TBI treatment setup relied on positioning patients supine on a custom built table and delivering prescribed radiation using a simple bilateral extended SSD. Rice bags were used to improve dose homogeneity, and testicular shielding was used for most male patients.

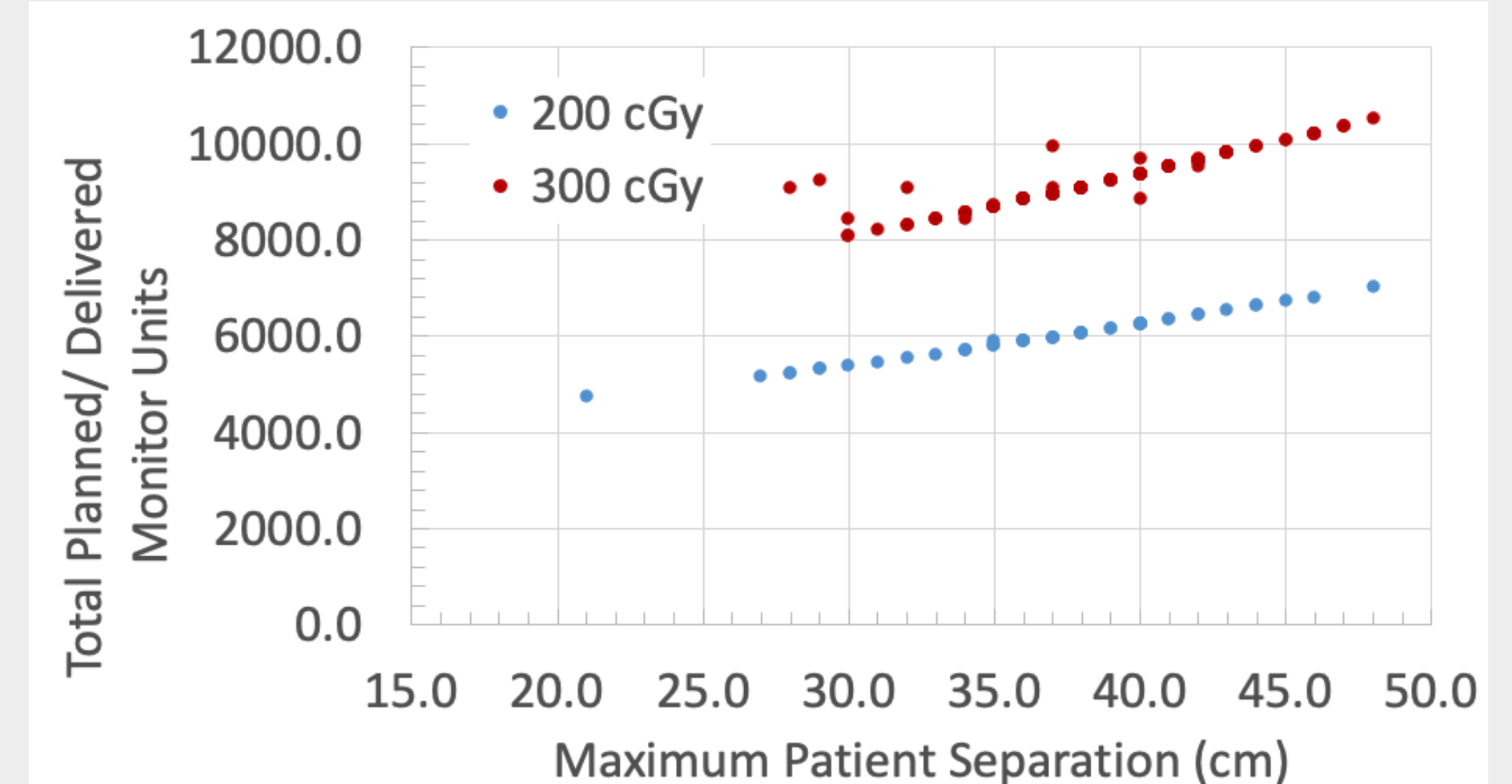


Figure 4. Planned and delivered monitor units according to the maximum patient separation reading.

III. TREATMENT DELIVERY & DOSIMETRY

- Time:** Treatment setup, verification and time was typically < **1 hour**.
- Setup verification:** Visual alignment based on TBI table marks and in-room lasers.
- In vivo:** In-vivo optically simulated detector (OSLD) measurements were conducted at 4 levels (shoulders, lung entry and exist, pelvis). Dose calculation vs. measurements were <10%

IV. CLINICAL OUTCOMES

- Survival (5-years):** 95.6%
- Treatment outcome:** **93.8% successful**, 5.1% graft failure, 1.2% new malignancy
- Morbidity:** 53.1% of patients were reported to develop post-TBI toxicities (of these Grade I: 57.5%, Grade II: 34.5%, Grade III: 8.0%). However, notably, all patients had concurrent treatment (chemotherapy, antibiotics, other).

CONCLUSIONS

- This experience in treating a **high volume of SCD patients receiving TBI** can be **used to inform technique commissioning and workforce/ load planning**.
- Most patients were from the Southern region, highlighting the need for more accessible, local comprehensive haematology services that include TBI.
- With rising immigration rates, **SCD incidence is expected to increase in North America and Europe**.
- Most patients were adults, and none required anesthesia.
- Due to the low prescription dose, lung shielding was not needed.
- For **high-volume TBI centres**, and given a single, low prescription dose a **simple, extended-SSD** with manual calculation meets **clinical, dosimetric, and logistical needs**.
- This technique provides a safe and reliable setup with **excellent clinical outcomes**, and improved treatment **time efficiency**.

CONTACT

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[1] World Health Organization. 2025. Sickle-cell disease Fact Sheet.
[2] Shdaifat E., et al. 2025. Economic Burden of Sickle Cell Disease in Saudi Arabia. Value in Health Regional Issues. Vol 45.
[3] Alzahrani M., et al. 2021. Non-myeloablative human leukocyte antigen-matched related donor transplantation in SCD.... British Journal of Haematology. 192(4).