Design of Patient Transfer Mechanism

ISSN 2395-1621

#1Bakul S. Shinde, #2Dr.Milind. S. Rohokale

1bacool.007@gmail.com
2rohokalemilind74@gmail.com

#12Department of Mechanical Engineering, Sinhgad Institute of Technology, Lonavala

ABSTRACT

Efforts to reduce the manual intervention associated with the patient handling is based on the tradition and personal experience. In India, the number of accidents is increasing every year. Transferring the patients from the accident spot to the hospital bed has always become an issue especially if the patient is suffering from spinal injury or multiple fractures. This task has to be performed with utmost care and safety of the patients. Handling the patient becomes a tough job for the attendant especially when there are multiple injuries. For an extremely wounded person or patients with orthopaedic conditions, it is said that their body is handled with least movement or jerk. But this is unavoidable when the patient is handled manually. Presently wheelchairs and stretcher are the commonly used mobility aid for indoor and outdoor purpose.Considering all the above problems there is a need for a stretcher to facilitate the disabled patient's mobility and to provide novel medical equipment for use in the Indian hospitals. A new concept of Stretcher is Designed which will minimize all the above said problems and ease in transferring the patients with utmost care safety and comfort.

Keywords— **Patient Transfer, Patient Handling, Mobility Aid, Care, Safety, Comfort,**

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Currently in India, A bed sheet or a Resin sheet is used to transfer the patient from the accident spot to the stretcher since the accident spot becomes inaccessible at times. This Resin Sheet is always kept on standby in all the ambulances in India.

Fig 1.Patient Taken out in Bed sheet

The number of disabled / injured individuals is increasing very year.Mobility aidsare useful for patients for transportation during accident cases. Stretchers are the most commonlyusedmedicalequipmentforthetransportationofpatients.Transferringthepatientsfrom stretchertothemedicalbedisalwaysanissuefortheattendantornurse.Although patient-lifting devices have been developed and commercialized, they are not widely used in nursing-care facilities in IndiaUnderstand ingt hevarious issuesregardingthemobilityequipmentandintroducingabetter designwillbeanassetforthemedicalfieldanda helpinghand for disabled individuals.Tasks involving the transfer of patients, such as lifting and moving a bedridden patient from a bed to a wheel chair and back, are among the most physically challenging tasks in nursing care. [3.]

Fig.2 Resin Sheet in an Ambulance

The various Equipment which are currently used day to day for transferring the patient to the Hospital bed are as follows.

1.1 Ceiling Lift Mechanism

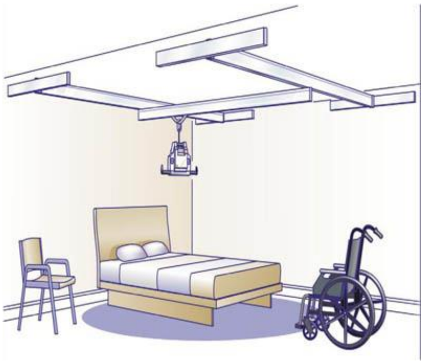

Fig 3. Ceiling lift Mechanism

1.2 Conventional Stretcher

Fig 4: Conventional Stretcher

Fig 5.Conventional Stretcher in an Ambulance.

1.3 *Conventional Sheet*

Fig 6. Conventional Sheet used as a Stretcher.

It becomes very difficult to handle the patients while transferring from the Stretcher to the Hospital bed by using the above equipment. If the patient has multiple injuries or fractures then it becomes a tedious task to transfer the patient to the Hospital bed and it also involves a number of person and very smooth handling.

Taking into considerations the various disadvantages of the above stretchers a New Proposed Stretcher can be designed which can eliminate the disadvantages of the above equipment to transfer the patient from twice to just once i.e. from the Accident spot to the Stretcher Trolley and form the stretcher trolley to the bed can be minimized to just transferring the patient from the accident spot directly to the hospital bed with minimum human intervention.

The New Design will facilitate and likely to overcome all the problems of Patient Handling and Transferring with care and comfort. This Design consists of a new horizontal Patient Transferring Mechanism from the Stretcher to the Hospital bed with minimum human intervention.

Our study shows that it is possible tosavethe tedious task of handling the patients carefully. Theproductwill thus likelybeanefficient mobilityaidin hospitals.

II. OBJECTIVE

To design a Stretcher Trolley to develop the available Stretcher for transferring the patient from the Stretcher to the hospital bed with minimum manual intervention.

III. PROPOSED MODEL

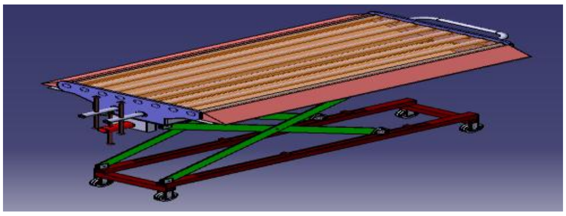

Fig 7. Scissor Mechanism

A. *Use of Height Adjustable Roller System for Patient Transfer*

With the help of a Simple Scissor Mechanism the Height of the Stretcher bed can be adjusted with the help of a Power screw which can be turned automatically or with the help of a handle as shown in the figure below.

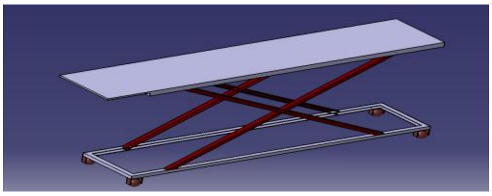

Fig8. Scissor Mechanism

B. Use of Roller Bed to Transfer the Patient Laterally

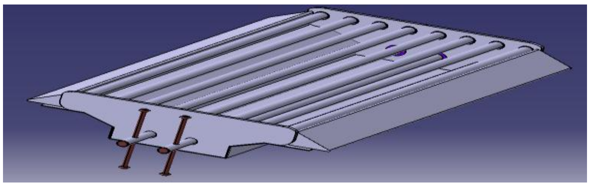

Fig 11. Proposed Roller Bed

If the patient has multiple fracture or injuries then it becomes a tedious task to manually lift the patient and transfer from one bed to another. Transferring the patient from roller bed to another bed will be much easier with less human intervention.

IV. DESIGN CONCEPT

Specifications for Stretcher

Mass of the Patient to be transferred- 200kg
Length of bed -1750mm
Width of bed- 800mm
Height Range- 750mm to 1050mm

A. Design of Idler Rollers

Width of the trolley can be equated to the following equation

$nD + (n-1)s = (\text{Width of the trolley} - \text{side flaps})$
$nD + (n-1)s = (800 - 100)$

Where,
n = Number of Rollers used over a width
s = Spacing between outside diameter and two roller
D = Diameter of Roller
Width of Trolley = 800mm
With of Side flaps = 100mm
Assuming $s = 50mm, D = 45mm$ and substituting in the above equation, $n \cong 8$
Considering 3 numbers of rollers lying below the patient and assuming uniformly distributed load over the entire rollers

$$W = \frac{200}{3} \times 9.81 \times \frac{1}{1750} = 0.3737\ N/mm$$

Material of Roller- Aluminium (6061-T6) Grade
Properties of Material
$Syt = 241MPa$, $Sut = 300MPa$
Calculating the Bending Moment as a simply supported beam with uniformely distributed load is given by

$$M = \frac{Wl}{2}x - \frac{Wx^2}{2}$$

Maximum B.M occurs at $x = \frac{l}{2}$

$$\therefore M = \frac{Wl^2}{4} - \frac{Wl^2}{8} = \frac{Wl^2}{8} = 143057.0313Nmm$$

Conditioning for Designing

$$\frac{Syt}{3} \geq \frac{143057.03 \times \frac{D}{2}}{\frac{\pi}{64}(D^4 - d^4)}$$

$$\frac{(D^4 - d^4)}{D} \geq 18139.0075$$

By substituting the various values of D and d
$D = 38mm$ and $thickness = 2mm$
$d = 38 - 4 = 34mm$
Checking for Shear Stress using Distortion Energy Theory
$Ssy = 0.57 \times 241 = 137.37\ MPa$
Now

$$\tau_{MAX} = \frac{4}{3} \times \tau_{AVG} \times FOS$$

$$= \frac{4}{3} \times \frac{326.987}{\frac{\pi}{4}(38^2 - 34^2)} \times 3$$

$$\tau_{MAX} = 5.7823MPA$$

$\tau_{MAX} \leq SSY$ Hence the Design is Safe against Shear.

Hence For Idler Roller Aluminium (6061 T6) with $D = 38mm$ and $d = 34mm$

B. Design of Bearing

Forces acting on Bearing
Radial Force acting on Bearing= F_r= 326.987N=P
Axial Force = F_a= 0
Speed of the Bearing= 60rpm
Inner Diameter of the Bearing= 38mm
Life of bearing in expected hours= 8000hours= $L_{10}h$
∴Life in Million Revolutions (L_{10}) =

$$= \frac{60 \times n \times 8000}{10^6} = \frac{60 \times 60 \times 8000}{10^6} = 28\ \text{Million Rev}$$

Dynamic Load Capacity of Bearing=c $P(L_{10})^{1/3}$

$\therefore c = 326.987 \times (28.8)^{1/3}$= 100.2928N

From Single Row Deep Groove Ball Bearing Catalogue Bearing Selected is 61808 where

$d = 40mm; D = 52mm; t = 7mm\ c = 4160N$
For the corresponding bearing with $d = 40mm$ the roller size can be selected as,
$D = 40mm; d = 36mm$ and $t = 2mm$
For Aluminium 6061 T6

$$\frac{D^4 - d^4}{D} = 22009.6 > 18139.0075$$

And $\tau_{max} = 5.48MPa < 139.057$
Roller Size
$D = 40mm; d = 36mm; t = 2mm; l = 1750mm$
Bearing Size $d = 40mm; D = 52mm; t = 7mm$
Number of Idler Rollers that are required are,
$nD + (n-1)s = 700$
$s = 55mm\ (Assumed); D = 40mm$
Substituting the values of s and D in the above equation,
$40n + (40-1) \times 55 = 700; n \cong 8$
Idler Rollers are also subjected to Deflection and Fluctuating Load,

Let the allowable Deflection for Idler Rollers be assumed as 3mm

For Simply Supported Beam with Uniformly Distributed Load, Deflection is given by

$$\delta = \frac{5Wl^4}{384EI}$$

Where,

$W = UDL\ Intensity$

$l = Length\ of\ Beam$

$I = Moment\ of\ Inertia$

$E = Modulus\ of\ Elasticity$

$$\therefore \delta = \frac{5 \times 0.3737 \times 1750^4 \times 64}{384 \times 80000 \times \pi \times (D^4 - d^4)}$$

Solving for $\delta = 3mm$

$D = 40mm; d = 24mm$

Checking for Fluctuating Load with $D = 40mm; d = 24mm$

Endurance Strength = Se'= $0.5S_{ut}$

Corrected Endurance Strength is given by

$Se = Ka\ Kb\ kc\ Kd\ Ke\ kf\ Se'$

$\therefore Se = 113.68MPa$

Now here the case is completely reverse loading in which the load is varying between Maximum and Minimum with mean equals to 0

$$Sa = \frac{MI}{Y} = \frac{143057.0313 \times 20 \times 64}{\pi \times (40^4 - 24^4)}$$

$Sa = 26.15MPa$

Using Goodman Criteria

$$\frac{Sa}{Se} + \frac{Sm}{Sut} = \frac{1}{n}$$

$$\frac{26.15}{113.68} = \frac{1}{n}$$

$\therefore n = 4.34$

Hence the calculated size is safe against Fluctuating load.

$\therefore$ Size for Idler Roller $D = 40mm; d = 24mm$ with Material Aluminium 6061 (T6 Grade)

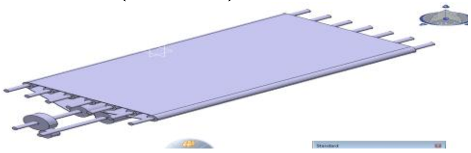

Fig.9 Belt Drive Mechanism

An Electrically driven Pulley can be used for operating a belt drive with the help of idler rollers. It can also be hand driven with the help of a rotatablehandle.

C. Design of Handle

The condition for the Force that needs to be applied at the handle is such that the moment produced at the driving roller by the handle should be greater than the resisting moment of the belt i.e $M > M_B$. By considering the outside diameter of Driving Roller as 40mm & keeping the inside diameter of Driving Roller as variable; $M_b = F_2 \times \frac{D}{2}$

$$M_b = 1669.7 \times 20 = 33393.4N.mm$$

Let F=10Kg= Driving Force gives Moment

$M = F \times A\ N.mm = 10 \times 400 \times 9.81 = 39240\ N.mm > M_b$

Material for Handle

Steel with $S_{yt} = 215MPa; E = 200 \times 10^3; G = 86\ GPa$

Handle can be modelled as a cantilever beam with force applied at one end. Handle shouldn't fail against the Bending Stresses, Shearing Stresses and Deflection Constraint

1. Bending Stresses

$$\frac{S_{yt}}{FOS} \geq \frac{MY}{I}$$

$$\frac{215}{3} \geq \frac{39240 \times D \times 64}{2 \times \pi \times D^4}$$

$\therefore D \geq 17.73mm$

2. Shearing Stresses

$$\frac{S_{sy}}{FOS} \geq \frac{4}{3} \times \tau_{avg}$$

$$\frac{0.577 \times 215}{3} \geq \frac{4}{3} \times \frac{10 \times 9.81 \times 4}{\pi \times D^2} \quad \therefore D \geq 2mm$$

3. Deflection Constraint

$$\delta \geq \frac{Pl^3}{3EI}$$

Let $\delta_{Permissible} = 1mm$

$$1 \geq \frac{10 \times 9.81 \times 400^3 \times 64}{3 \times 200 \times 10^3 \times \pi \times D^4}$$

$\therefore D = 16.57mm$

$\therefore$From three conditions Diameter of a Handle can be chosen as 18mm.

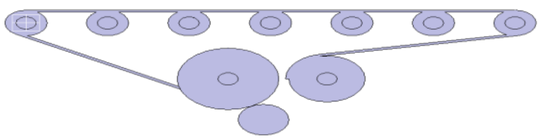

Fig 10.Driving Roller driving the Idler Rollers.

D. Design of Driving Roller

Material for intial iteration values

Aluminium 6061(T6 Grade)

$S_{yt} = 241MPa;\ S_{ut} = 300MPa; E = 80 \times 10^3 MPa\ \&\ G = 26 \times 10^3 MPa$

Driving Roller shouldn't fail against

1. Torsional Stresses

$$\frac{Ssy}{FOS} \geq \frac{M_t \times r}{J}$$

In this case we have considered $D = 40mm\ and\ d$ as a design variable.

$$\frac{0.577 \times 241}{3} \geq \frac{39240 \times 32}{\pi \times 40^3(1 - (d/40)^4)}$$

$\therefore \boldsymbol{d \leq 37.8mm}$; **Hence d**$\boldsymbol{\leq 37.8mm}$

2. Angular Deflection Constraint

Let the permissible $\theta = 20°$ Assumed

$$\frac{M_t \times l}{J \times G}$$

$$\frac{2 \times \pi}{180} \geq \frac{39240 \times 200 \times 32}{\pi \times (40^4 - d^4) \times 26 \times 10^3}$$

$$\therefore \frac{\pi}{90} \geq \frac{7082.95}{(40^4 - d^4)}$$

$$\therefore \boldsymbol{d \leq 36.58mm}$$

3. Bending Stresses

This roller can be considered as a simply supported beam with UDL.

$$\therefore \frac{Syt}{FOS} \geq \frac{MY}{I}$$

$$\frac{241}{3} \geq \frac{344148.4375 \times 64}{2\pi \times 40^3}$$

$$\therefore \boldsymbol{d \leq 30.042\ mm}$$

4. Deflection Constraint

Let $\delta_{permissible} = 3mm$

$$\therefore \delta \geq \frac{5Wl^4}{384EI}$$

$$\therefore 3 \geq \frac{5 \times 0.899 \times 1750^4 \times 64}{384 \times 80 \times 10^3 \times \pi \times (40^4 - d^4)}$$

$$\therefore \boldsymbol{d \leq 21.3mm}$$

From the above 4 constraints the Standard Size of the Driving Roller selected is $\boldsymbol{D = 40mm; d = 18mm}$

E. Design of Bearing of Driving Roller

Driving Roller will be mounted on the frame by using deep groove ball bearing.

Radial Force (F_r) = 1573.79

Axial Force (F_a) = 0

Speed of Bearing= 60rpm

Inner Diameter of the Bearing (d) = 40mm

Life of bearing in expected hours= 8000hours

Life in Million Revolutions (L_{10}) = 28.8 Million Revolutions

Dynamic Load Capacity of Bearing C= $(L_{10})^{1/3}$

$\therefore C = 1573.79 \times (28.8)^{1/3}$

$\therefore \boldsymbol{C = 4824.04\ N}$

From Single Row Deep Groove Ball bearing Catalogue, the bearing Selected is 16008,

$\boldsymbol{D = 68mm; d = 40mm\ \&\ t = 9mm}$

V.CONCLUSION

In this way, the manual handling of patientcan should be totally eliminated for the safety of Patient. If Automatic lateral transfer of patient, with adjustable height is made available, then the patient will have to be handled only once i.e. to transfer from the accident spot to the Stretcher trolley, the patient will not be required to be handled manually further. Mechanical linkage for height Adjustment can be replaced by a pneumatic or a hydraulic system.

REFRENCES

[1] Sreerag C S, Gopinath C, ManasRanjan Mishra, *Design and Development of conceptual Wheelchair cum Stretcher*,Department of Design, M. S. Ramaiah School of Advanced Studies, Bangalore 560 058.

[2] Toshiharu Mukai, Shinya Hirano, Hiromichi Nakashima, YoKato,YukiSakaida, ShijieGuo and Shigeyuki Hosoe, *Development of a Nursing-Care Assistant Robot RIBAThat Can Lift a Human in Its Arms.*

[3] Prof.S.A.Kedar, GandhaliDeshpande, AditiBhusawalkar, Maithili Yawalkar, and KangkanaSarmah.*Lateral Transfer Device for Hospital Stretcher*, Cummins College of Engineering for Women Pune

