Functional Outcome Following Lower Limb Amputation

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Epidemiology -incidence

- Approx. 180,000 amputations per year in US
- 150,000 major amputations (BK 2/3, AK 1/3)
- Diabetes and dysvascular disease= 82% (97% lower limb)
- Trauma = 16 % (68 % are upper limb)
- Cancer = <1 % (75% are lower limb)
- Congenital = < 1 % (60% are upper limb)

Epidemiology-prevalence

- Approx 2 million amputee survivors in US (ACA)
- Less than half are diabetic/dysvascular with 4x higher prevalence in males and African Americans
- The majority are trauma related
- Age groups?

Survival

- Survival following amputation surgery due to dysvascular disease:
  1. Peri-operative (30 days)= BKA- 94%
     AKA- 83%
  2. 1 year= BKA -74% AKA-50 %
  3. 5 year= BKA- 48% AKA- 22%
- Survival following trauma/cancer is significantly better

Morbidity -dysvascular

- Revision surgery in dysvascular population = 18-25% with 10% converting BKA to AKA
- Amputation of remaining limb :
  1. 1 year= 11%
  2. 3 years= 44%
  3. 5 years= 53%

How Do We Measure Functional Outcome?

- Any wearing of the prosthesis
- Any use of the prosthesis
- Household ambulators
- Community ambulators
- Return to previous activity
- Medicare Functional Levels (0-4)

Which Factors Affecting Outcome are Studied the Most?

- Age
- Cause of amputation
- Level of amputation
- Co-morbidity

The Dilemma

Unlike upper limb amputation, there are several different clusters of patients with distinct ages and etiologies for amputation. Therefore, predicting functional outcome needs to address each group separately.

Young traumatic

Middle-age traumatic

Middle-age dysvascular

Older dysvascular

Measurement Tools

Kerstein Functional Levels (ADL and mobility)

Tables 7. Criteria for Prosthetic Goal and Achievement (Kerstein 1975)

5	**Full restoration**	Perform all self-care activities Walk 440 yd. with prosthesis on level and uneven terrain Climb and descend stairs without handrails Use public transportation
4	**Partial restoration**	Perform all self-care activities Walk 100 yd. with prosthesis, but limited terrain Climb and descend stairs with handrail Use public transportation
3	**Self-care**	Able to dress, perform all toilet activities, put on and remove prosthesis without assistance Walk 50 ft with prosthesis Climb and descend stairs with assistance Unable to use public transportation
2	**Cosmesis plus**	Stand and turn using prosthesis Require personal assistance for movement
1	**Cosmesis**	Prosthesis of no functional value

Narang Functional Levels (mobility only)

Table 9. Amputee Classification of Functional Levels (Narang, 1984)

1	Totally independent
2	Independent with one cane or crutch
3	Independent in home ambulating with prosthesis, but need wheelchair for outdoor activities
4	Independent ambulant with crutches, but not wearing a prosthesis.
5	Non-ambulatory except in wheelchair.

Francis Mobility Levels (mobility only)

Table 10. Grading of Mobility in Amputees Six Months After Amputation (W. Francis, 1987)

A	Chairbound
B	Walking with aids but without a prosthesis
C	Walking with a prosthesis
C1	Occasionally
C2	Daily indoors
C3	Daily indoors and outdoors
C4	Indoors, outdoors and stairs

Hanspal Mobility Levels (mobility only)

Table 11. Amputee Mobility Grades (Hanspal, 1991)

1	Limb wearing abandoned or use of cosmetic limb only.
2	Wears prosthesis is only for transfers or to assist nursing. Walks only with therapist or care giver.
3	Indoor walker only, using walking aids e.g. sticks, crutches or walker frame.
4	Indoor and outdoor walking though with regular use of walking aids.
5	Independent indoor and outdoor without walking aids except occasionally for confidence or to cover difficult terrain or weather conditions.
6	Normal and near normal gait.

Siriwardena Walking Index (mobility only)

Table 12. Walking Ability Index (Siriwardena, 1991)

1	Normal gait
2	Abnormal gait
3	Use of 1 cane or crutch
4	Use of 2 canes or crutches
5	Walking with frame only
6	Unable to walk (requiring a wheelchair)

Medicare Functional Levels 1995
(attempts to correlate function to prosthetic components)

- Level 0 - Patient is non-ambulatory
- Level 1 - Transfers or limited household
- Level 2 - Limited community ambulator
- Level 3 - Unlimited community ambulator
- Level 4 - High energy activities

Other Functional Assessment Tools

- Barthel Index and FIM score are very broad based tools with very little focus on mobility
- Bob Gailey's Amputee Mobility Predictor (AMP) tries to assess mobility function with and without a prosthesis, and to predict maximum potential

Selected Study Results

Gailey 1999

- Studied 166 older amputee patients to determine validity of Medicare Functional Levels
- Found some consistency in amputee performance
- Found inconsistencies in assignment of the prosthetic components

6 Minute Walk Distance

Table 33. Six-minute Walk Distance (metres) Means, Standard Deviations and Range

	Level 1 n=7	Level 2 n=43	Level 3 n=66	Level 4 n=39
mean	49.86	189.89	298.64	419.76
std dev	29.82	111.31	102.37	86.15
range	4-96	16-480	48-475	264-624

6 Minute Walk Velocity

Table 34. Six-minute Walk Velocity (m/s)
Means, Standard Deviations and Range

	Level 1 n=7	Level 2 n=43	Level 3 n=66	Level 4 n=39
mean	0.19	0.58	0.85	1.13
std dev	0.10	0.28	0.29	0.29
range	.05-0.36	0.12-1.33	0.13-1.55	0.12-1.73

Medicare Functional Levels vs. Foot Worn

Table 30. MFCL Prescription Versus the Frequency and Percentage Prosthetic Foot K Modifier Worn by Amputee

Frequency Percent Row percent	K0	K1	K2	K3	Total
Level 0					
Frequency	7	0	0	0	7
Percent	100	0.0	0.0	0.0	
Level 1					
Frequency	3	7	1	0	11
Percent	27.27	63.64	9.09	0.0	
Level 2					
Frequency	0	23	10	9	42
Percent	0.0	54.76	23.81	21.43	
Level 3 & 4					
Frequency	2	21	17	66	106
Percent	1.89	19.81	16.04	62.26	
Total	12	51	28	75	166

Medicare Functional Levels vs. Knee Worn

Table 31. MFCL Prescription Versus the Frequency and Percentage Prosthetic Knee K Modifier Worn by Amputee

	K0	K1	K2	K3	Total
Level 0					
Frequency	4	0	0	0	4
Percent	100.0	0.0	0.0	0.0	
Level 1					
Frequency	2	2	2	0	6
Percent	33.33	33.33	33.33	0.0	
Level 2					
Frequency	1	8	4	8	21
Percent	4.76	38.10	19.05	38.10	
Level 3 & 4					
Frequency	3	4	3	46	56
Percent	5.36	7.14	5.36	82.14	
Total	10	14	9	5	87

Burger 1997
young, traumatic amp.
20 year follow-up

- 70 % used prosthesis > 7 hours per day
- 50 % walked without any aids
- 50 % climbed > 20 steps per day

Walker 1994
young, traumatic

- 80 % trans-tibial amputees ambulated independently with no assistive device
- 70 % trans-femoral amputees ambulated independently with no assistive device

Keigel
young, traumatic

Return to sports following amputation:

- Swimming- nearly 100 % of patients who swam before amputation returned to swimming
- Running- rate of regular runners dropped from 28 % to 5 % after amputation
- Golf- number of patients playing golf regularly increased from 28 % to 35 % after amputation

Uiterwijk 1997
older, PVD, 1 yr

- 59 % using prosthesis 1 yr post-op
- 48 % ambulating independently (with or without assistive device)

Valentine 1996
older, PVD, 2-3 yrs f/u

- 10 % died
- 45 % using wheelchair
- 10 % household ambulators with prosthesis
- 22 % community ambulators with prosthesis

Ng 1996
older, PVD, 8 yr f/u

- 93 % wore prosthesis
- 83 % used prosthesis regularly
- 50 % household ambulators
- 40 % community ambulators
- 10 % wheelchair users (with or without prosthesis)
- Included only survivors !!

Sapp 1995
older, PVD

- 77 % used prosthesis regularly
- 16 % abandoned prosthesis

Stewart 1993
older, PVD

- 87 % of TTA wore prosthesis
- 70 % of TFA wore prosthesis

Finch 1980
older, PVD

- 95 % returned home to live
- 75 % fitted with prosthesis and used for any activity in household
- 50 % ambulated in the community with prosthesis

Pinzur 1992
older, PVD

- 84 % of all amputees returned to within 1 level of previous mobility
- Increased functional use correlated to hours of wearing time
- Use of assistive devices decreases with more distal amputation

Holden 1987

- Determined that older patients needed to take a minimum of 600 steps per day to live alone in an apartment
- Minimum of 1100-1400 steps per day to live in a 1-2 level home

Forthington
J Am Med Dir Assoc 2012

- Literature review of elderly population with lower limb amputation >6 months after discharge
- Less than half achieved even household ambulation with a prosthesis

Sansosti
J Am Pod Med Assoc 2017

- Retrospective review of discharges from an urban tertiary care hospital, 1 year after lower limb amputation.
- Overall rate of ambulation was only 30%, but BKA was 50% and AKA was 20%

Chopra
J Vasc Surg 2018

- 10 year retrospective review of lower limb amputation 1 year after discharge (dysvascular patients)
- Overall ambulation rate was 46% (90% BKA, 10% AKA)
- Negative factors were obesity, dmentia, dialysis, low H/H

Select studies to asses predictive factors

Kalbaugh 2006

- Studied 434 patients comparing obese to non-obese amputees
- Obesity did not affect daily use or functional level

Schoppen 2003

- Studied 46 older, dysvascular patients
- Found better outcomes:
  - Younger age
  - No cognitive impairment
  - Able to balance on 1 leg

Davies 2003

- Studied 281 dysvascular patients
- All patients under 50 ambulated in home and community
- Over age 50, only 50% of TTA and 25% of TFA ambulated in the community

Kahle
Technol Innov 2016

- Literature search 2007-15 for predictive factors for ambulation following lower limb amputation
- Etiology, physical fitness, pre-morbid living situation, lower amp level, younger age, less comorbidities had positive effect on prosthetic use

Bin Saeed
J Pak Med Assoc 2015

- Prospective study of 104 patients with LLA
- Higher level of amp, CVA, ESRD, cognitive impairment, and female gender were associated with poor functional outcome

Penn-Barwell
Injury 2011

- 10 year literature review assessed over 3000 patients with LLA from trauma for QOL and mobility
- More distal level of amp (BKA vs AKA) had much higher percentage of patients that walked >500 meters.
- Knee dis-artic also walked more than AKA, but wore the prosthesis less

Eskridge
Am J Phys Med Rehab 2019

- 82 patients with traumatic LLA from the Wounded Warrior Project were assessed for basic mobility skills
- Level of amputation was the primary factor in functional outcome with more distal amputation (BKA) doing better than AKA or bilateral amp

Componentry

Hofstad
Cochrane Database Review 2004

- Database and literature review from 1982-2003 to assess the relationship of prosthetic foot selection to functional mobility
- Dynamic response feet were better than SACH feet for BKA during fast walk or incline/decline
- For AKA there is limited evidence that dynamic response feet improve energy efficiency during gait on level surface

Cumming
Cochrane Database Update 2015

- There were no new good studies (RCTs) from 2005-2015 for the population over 60 with AKA regarding prosthetic design or componentry related to functional outcome

Wurdeman
Assist Technol 2018

- Studied 450 patients with LLA to compare MPK users to non-MPK users and BKA
- Using the PLUS-M tool for functional outcome, the MPK users did better than non-MPK users, but not as well as BKA

Conclusions

- There is no consistent functional outcome measure being used for successful amputee prosthetic rehabilitation
- About 80 % of young, traumatic amputees ambulate with a prosthesis
- About 50 % of older, dysvascular amputees ambulate with a prosthesis
- Morbidity and mortality is very high in dysvascular patients (50/50 rule)

Conclusions

- Only predictive factors seem to be younger age and amputation below knee
- No good correlation yet between prosthetic componentry and functional outcome. Soft evidence for dynamic response feet and MPK knees.

Thank You