Cachexia, Artificial Intelligence and Smartphones

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Cancer Cachexia

• Potential of AI in improving cachexia assessments
• Current examples of AI and cachexia domains
  nutrition, imaging, genetics
• Limitations and opportunities
AI

- Machines imitate human thought processes
- Ability to learn using digital binary logic of computers and then simulate the capacity for abstract, creative, deductive thought
- Rather than being taught everything step by step, machines can be programmed to think like humans, by observing, classifying and learning from mistakes
AI and Artificial Neural networks

- ANN “a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs” Robert Hecht-Nielsen
- Use Reinforced learning and deep neural networks
- ANN enables discovery of more complex relationships in data than traditional statistical modes
- ANN are adaptive and can learn from data -this ability does not depend upon the prior knowledge of rules and only broadly resembles the original training data
Definition of Cancer Cachexia

- Multi-factorial syndrome
  - Characterized by ongoing loss of skeletal muscle ± loss of fat mass
  - Cannot be reversed fully by conventional nutritional support
  - Leads to progressive functional impairment
  - *Complex, imprecise*

**Weight loss >5% over 6 mo** that cannot be attributed to simple starvation
  or
  **BMI <20 + weight loss >2%**
  or
  Appendicular skeletal muscle mass index consistent with **sarcopenia + weight loss >2%**

Stages of Cancer Cachexia

- **Pre-cachexia**
  - Weight loss ≤5%
  - Metabolic/endocrine change

- **Cachexia**
  - Weight loss >5%
  - Reduced food intake/systemic inflammation

- **Refractory cachexia**
  - Low performance score
  - Immunocompromise, <3-mo expected survival

- **Identify anabolic opportunity; determine clinical trial inclusion**
- **Avoid using medication or additional resources on non-cachexia patients**
- **Need more patient data to distinguish between stages**

Survival is a function of BMI and % weight loss in 8160 patients.

Panels A to C represent a 5 × 5 matrix analysis of the five categories of BMI and five categories of %WL for a total of 25 possible combinations. The (A) sample size, (B) median overall survival (months), and (C) unadjusted estimated hazard ratios (HRs; HR, 1.0) are presented for each cell. (*) Reference categories are BMI ≥ 28.0 kg/m2 and weight stable ± 2.4%. Different colors represent significant differences (P < .05) in median overall survival and HRs within and between cells of the matrix. Panel D represents the BMI-adjusted WL grading system (grades 0 to 4).

Median survival by grade
0=20.9 months
1=14.6
2=10.8
3=7.6
4=4.3
Figure 4  Bar charts for each baseline weight loss grade (0–4) showing the likelihood of improvement to preceding or progress to subsequent grades or death at 1, 2, and 3 months of follow-up.

Change in weight loss grade:
- Improved
- No change
- Progressed
- Dead
Additional cachexia domains

• Body composition¹
• Patient reported outcomes
  Appetite²
  Nutrition Impact symptoms³,⁴
  Fatigue and function⁵
• Dietary intake⁶
• Physical Function⁷
• Chronic inflammation⁸
• Other- chemo & endocrine dysfunction⁹
• Genomics
Genomics and Cachexia

• Predict risk, prognosis, Rx response for cachexia based on genomic data
• Muscle reserve may be a factor in developing cachexia
• Allele variations are associated with muscle mass & strength
• myostatin (GDF8, K133R), CNTF and receptor, vitamin D receptor (VDR Bsml), androgen receptor gene (CAG repeats), cyclin-dependent kinase inhibitor 1A
• SNPs of ACE and TNF associated with cachexia

Morley JCSM 2017, Johns JCSM2017
Genomics, AI and Cachexia

- New insight into genetics of lean body mass and sarcopenia
- Lean body mass is a highly heritable trait
- A meta-analysis of genome-wide association studies for whole body lean body mass in >38000 individuals
- Five novel genetic loci were significantly associated
  - for whole body lean mass and for appendicular lean mass

- Future: Genomics England project=100000 genomes sequenced
- 1 sequenced genome=200 GB
- Cost $1500 will decrease to $100

Kiel Nat Commun. 2017
Extensive muscle wasting can be obscured by large fat mass

Fearon, K. et al. (2012) Understanding the mechanisms and treatment options in cancer cachexia
Patients with cancer cachexia by the conventional criterion (involuntary weight loss) and by two additional criteria (muscle depletion and low muscle attenuation) share a poor prognosis, regardless of overall body weight.
AI identifies aging signals in CT scans

- Application of pattern recognition and machine learning as a tool for analyzing medical images
- CT scans of abdominal L4 sections (Baltimore Long Study Aging) n=1092
- Method: supervised machine learning and generic image descriptors
- Goal: insight into tissue changes (texture and morphology) with aging

- Robust aging signal found
- Males > Females
- Aging signal predominantly in adipose tissue

Orlov Acad Radiol. 2017
| **Goals** | - Identify those at increased risk  
- Identify patients early  
- Monitor relevant outcomes  
- Incorporate a multidisciplinary approach |
|**Assessment Tool** | - Symptom severity assessment including appetite (e.g. ESAS)  
- Checklist of nutritional impact factors and weight loss (e.g. abbreviated PG-SGA)  
- Physical performance (e.g. SPPB, handgrip) dynamometer |
|**Multidisciplinary* Management** | - Physician = Pharmacological symptom management, education  
- Dietitian = Nutritional counseling, protein and calorie goal  
- Physical Therapist = resistance and aerobic exercise, fall prevention  
- Psychologist = reframing eating, conscious control, body image  
- Nurse = education, reinforcement of management plan, phone contact |
|**Monitor Key Outcomes** | - Weight change, BMI  
- Appetite  
- Fatigue, Nutritional impact symptoms and overall symptom burden  
- Physical performance  
- Body composition |
Nutrition-Related Mobile Apps

- 58% U.S own smartphones
- Cost of Apps
- Dietician/expert consult available?
- Free trials
- Syncs with other apps and devices
- Reduce recording burden
Image recognition services estimate nutritional values, dietary assessment, and management.
Smartphone Applications for Promoting Healthy Diet and Nutrition: A Literature Review

- 193 articles identified in the searches
- 9 RCT’s
- Comparisons to web-based app, tracking with paper, smartphone plus counseling, health education
- Use of smartphone apps associated with better dietary compliance for lower calorie, low fat, and high fiber foods, physical activity levels \( (p=0.01-0.02) \) more weight loss \( (p=0.042-<0.0001) \)

Coughlin SS Jacobs J Food Nutr. 2015
Popular Nutrition-Related Mobile Apps

- Objective: analyze main features of the most popular nutrition apps
- Compare strategies and technologies for dietary assessment and user feedback
- 13 apps qualified based on search terms and popularity
- High number of installs indicates interest for diet monitoring and recommendation
- All apps collecting dietary intake used same nutrition assessment method (food diary record) and technologies for data input (text search and barcode scanner)
- Image recognition, natural language processing, artificial intelligence, *not* identified.
- None of the apps had a decision engine capable of providing personalized diet advice

Franco J. MIR Mhealth UHealth, 2016
Mobile Apps and food recognition
A Novel Mobile Phone App (OncoFood) to Record and Optimize the Dietary Behavior of Oncologic Patients  

Pilot Study

- feasibility and applicability of a novel mobile app to assess and evaluate dietary behaviors
- 1400 nutritional records analyzed
- App=simple, set goals, recording the daily intake, a comparison of nutrient targets and current status
- All patients received nutritional analysis and nutritional counseling
- 12 also used the app vs control
- Weight and body composition evaluated after 4 weeks
Oncofood app screenshots

Nutritional goals and weight

Daily food record
Keyboard or voice

Nutritional goals met
Opportunities

- Easy, accurate dietary records with image recognition
- Show patterns of protein and daily calorie consumption, along with energy expenditure
- Motivational Feedback to modify behavior
- Combined with data from shopping, grocery delivery services, app users are guided to order groceries using recipes that better replace macronutrients and taste better
Internet of Medical Things

- Tracking physical activity
- Overcoming inaccuracy
- Interconnected devices
- Medical and non-medical
Summary AI and cachexia

- Enhance assessment of body composition, muscle quality, calorie needs, metabolic rate, physical activity, muscle risk
- Enhance screening and prediction for cachexia and identify clinically relevant pre-cachexia/cachexia conditions
- Enhance assessment + management of dietary patterns and behavior
- Individualize management for a multi-domain, heterogeneous syndrome
- Underserved gain increased access to assessment & Mx
- Identify effective pharm Rx (old, repurposed, new)
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