



# Early-Stage Lymphedema Detection and Conservative Treatment

Eun Joo Yang, MD.,PhD.

Associate Professor

Department of Rehabilitation Medicine

Seoul National University Bundang Hospital



# List

- Surveillance program for lymphedema
  - Clinical staging and severity of lymphedema
  - Early diagnosis of lymphedema
  - Differential Diagnosis
  - Conservative treatment with Surveillance program
- Real world management with IoT
  - Exercise program with ICT for high risk of lymphedema
  - Future step

# Breast Cancer and Lymphedema

Diagnosis



Acute Cancer Treatment



Survivorship Care Continuum



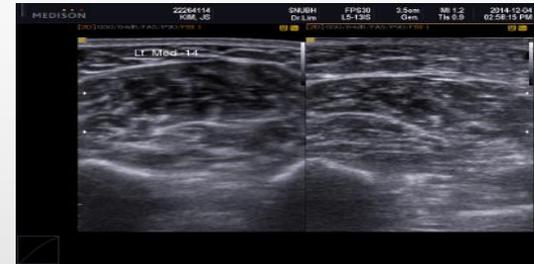
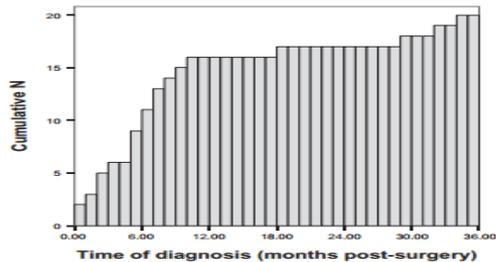
No impairments



Impairments

Risk factor

Natural course



# Clinical Staging of Lymphedema

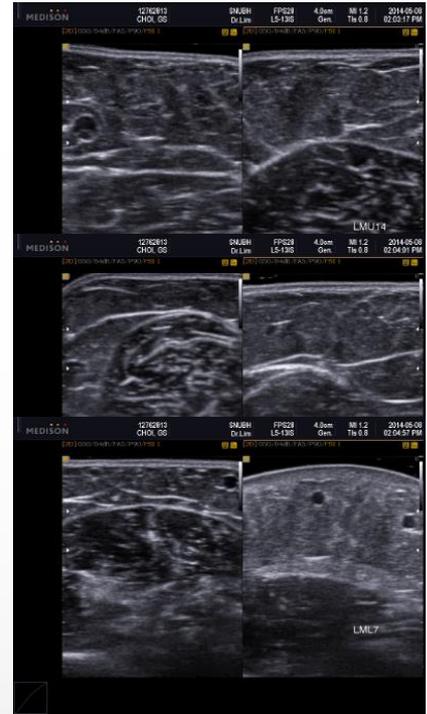
TABLE 1.

Clinical Staging and Severity According to the International Society of Lymphology Consensus Document

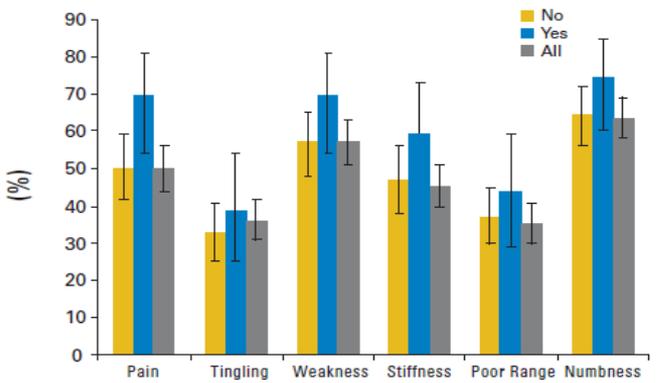
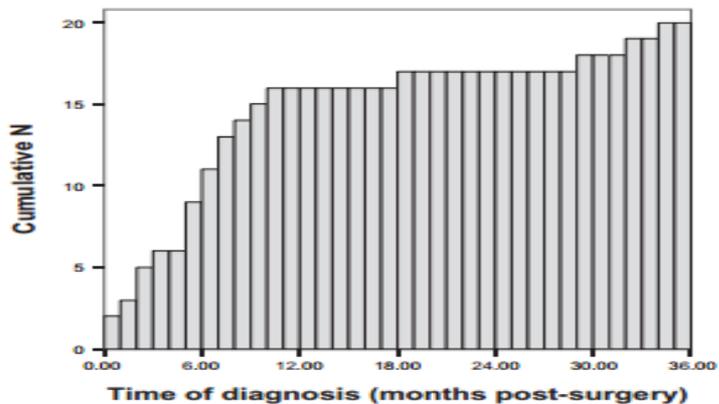
Clinical Stage	Description
0	A subclinical stage where swelling is not seen despite underlying changes in the lymphatic system
I	The initial stage of swelling which can be transient and where simple elevation can alleviate swelling
II	Swelling is constant and pitting without resolution using elevation
III	The tissue has become hard and fibrotic with associated skin changes
Severity	based on volume differences between affected and contralateral limb in unilateral presentation mild = <20% increase; moderate = 20%-40% increase, severe = >40% increase

Reprinted with permission of *Lymphology*.<sup>28</sup>

- A disruption of the lymphatic system
  - The accumulation of fluid in the interstitial tissue space (ECF)
  - Clinically manifests as swelling of the arm, breast, shoulder,
  - Later stages of lymphedema : fibrotic and adipose tissue



# Natural Course of Lymphedema



**Table 3.** Time Course of Lymphedema\* in First 3 Years of Study Among 433 Respondents With 3 Full Years of Follow-Up

Lymphedema	Respondents		Month of First Lymphedema			No. of Person-Months With Lymphedema Present		
	No.	%	Mean	Median	Range	Mean	Median	Range
No lymphedema	283	65.4						
Any lymphedema	150	34.6	8.5	5	0-33	17.4	15.5	2-36
Acute mild†	24	5.5	13.4	13.5	2-33	3.6	3.5	2-5
Chronic mild†	20	4.6	16.5	18	0-30	19.5	18	6-36
Improving: mild → none†	30	6.9	6.3	4.5	0-21	12.6	11	6-27
Wax/wane: mild ⇌ none†	26	6.0	4.7	4	0-15	19.0	18.5	5-30
Acute moderate/severe	2	0.5	18	18	4-32	4	4	4-4
Chronic moderate/severe	10	2.3	9.1	7	1-25	26.9	29	11-35
Improving: moderate/severe → mild/none	4	0.9	2.8	2.5	0-6	24.5	26	10-36
Progressing: mild → moderate/severe	10	2.3	9.4	6.5	0-27	26.5	29.5	8-36
Wax/wane: moderate/severe ⇌ mild/none (regardless of initial degree)	24	5.5	3.3	2	0-22	26.1	27	14-35

\*Any lymphedema was defined as a degree score greater than 0 and the limb on the side of surgery was larger. Mild lymphedema was defined as a degree score of 1 to 3. Moderate/severe lymphedema was defined as a degree score of 4 to 9.

†Lymphedema did not progress beyond mild.

Acute lymphedema 60%

*Norman et al., J Clin Oncol 2009;27:390-397*

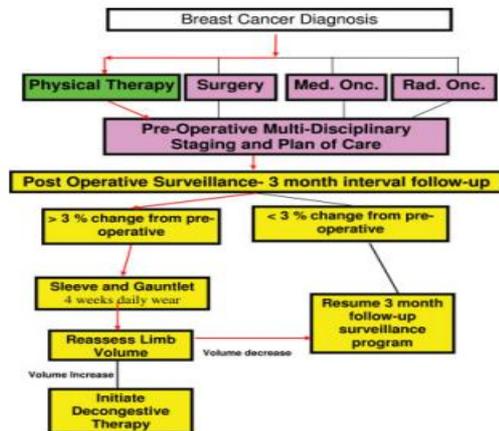
Chronic and/or progressive lymphedema : 30-40%

Fluctuating lymphedema : 15-22%

**Fig 1.** women with symptoms present during baseline (6 months after surgery) assessment. No lymphedema from 6 to 18 months after surgery (no, n=128)

lymphedema at some point during 0 to 18 months after surgery (yes, n=30)

# Preoperative assessment



**FIGURE 1.** Clinical pathway for the Prospective Physical Therapy Model of Care. Med. indicates medical; Onc., oncology; Rad., radiation.

**TABLE 4** Comparison of Upper Limb Volume Changes (in mL and %) Between the Control and Lymphedema Groups at Baseline, Onset of Intervention, and Follow-up

Variable	Control group: Mean ± SD			Lymphedema group: Mean ± SD			P
	UL volume, mL	Change, mL	Change, %	UL volume, mL	Change, mL	Change, %	
<b>Unaffected UL volume</b>							
Baseline	1253 ± 295			1315 ± 344			.375
Onset of intervention	1255 ± 304	2 ± 96	0.2 ± 7.2	1328 ± 355	13 ± 76	1.1 ± 6.7	
Follow-up	1252 ± 294	-1.3 ± 112	0.2 ± 8.7	1341 ± 351	26 ± 83	2.2 ± 7.3	
<b>Affected UL volume</b>							
Baseline	1256 ± 291			1331 ± 347			.005*
Onset of intervention	1259 ± 288	2.7 ± 89	0.5 ± 6.6	1414 ± 378	83 ± 119	6.5 ± 9.9	
Follow-up	1258 ± 279	2.3 ± 103	0.7 ± 7.9	1377 ± 341	46 ± 103	4.1 ± 8.8	

UL indicates upper limb; SD indicates standard deviation; UL, upper limb.

\* P < .05 is significant upper limb volume for between group, baseline-affected, and baseline-unaffected upper limb volume tested by repeated-measures multivariate analysis of variance.

# Effectiveness of early physiotherapy to prevent lymphoedema

**Table 2** | Comparison of secondary lymphoedema in groups

Group	Early physiotherapy group (n=59)	Control group (n=57)	Odds ratio (95% CI)	P value
No (%) with lymphoedema	4 (7)	14 (25)		
Early physiotherapy v control*	0.28 (0.10 to 0.79)†	—	0.22 (0.07 to 0.73)	0.010
Early physiotherapy v control‡	—	—	0.22 (0.07 to 0.72)	0.013

\*Crude effect.

†Risk ratio (95% confidence interval).

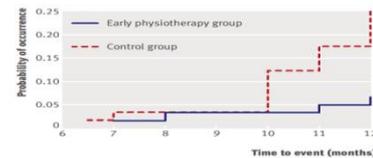
‡Adjusted for body mass index.

**TABLE 3** Time to Lymphedema Diagnosis, Intervention, and Follow-up

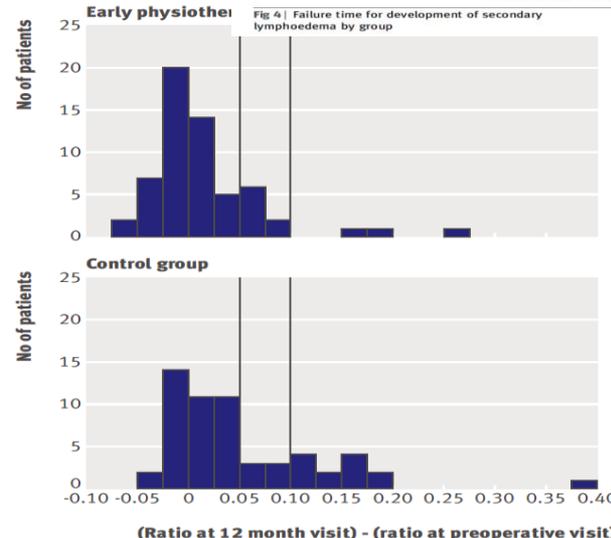
Variable	LE group only	
	Mean ± SD	Range
Time to diagnosis of LE, mo*	6.9 ± 4.3	1-18
Duration of intervention, wk	4.4 ± 2.9	2-12
Postintervention follow-up, mo	4.8 ± 4.1	2-24

LE indicates lymphedema; SD, standard deviation.

\* Onset of intervention.



**Fig 4** | Failure time for development of secondary lymphoedema by group



# A Prospective Surveillance Model for Physical Rehabilitation for Women with Breast Cancer

## Trajectory of Medical Management

*Breast cancer diagnosis and treatment planning*

*Post-operative period*

*Adjuvant treatment and survivorship care*

### Pre-operative rehabilitation: evaluation and education

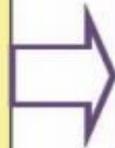
Assessment of relevant baseline measures prior to surgical intervention

#### Impairment identification and management

- Upper Extremity and Trunk
  - ROM and strength
  - Limb volume
  - Activity limitations and performance restrictions
- Pain
- Fatigue
- Function
- Weight

#### Health Promoting Skills and Behaviors

- Level of activity and function
- Provide post-operative therapeutic exercise program
- Education for post operative care
- Assess presence of pre-morbid conditions and the extent of their impact on function and future risk for impairment
- Assess weight and weight management strategies



### Early post-operative rehabilitation: re-assessment and exercise program

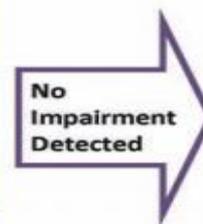
Repeat pre-operative tests and measures. Assessment should consider the patient, treatment and behavioral characteristics.

#### Impairment identification and management

- Upper Extremity and Trunk
  - ROM and strength
  - Limb volume
  - Activity limitations and performance restrictions
- Pain
- Fatigue
- Function
- Weight

#### Health Promoting Skills and Behaviors

- Level of activity and function
- Education for prevention and early detection of common treatment-related sequelae and maintenance of healthy lifestyle behaviors and weight management
- Exercise\*
  - Evaluation of activity limitations
  - Individualized exercise prescription
  - Referral to appropriate exercise program if needed



### Ongoing surveillance

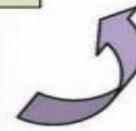
Repeat measures and assess for change. Take relevant baseline measures prior to adjuvant intervention(s). Frequency and duration of interval follow up is patient dependent. A Multi-disciplinary approach is optimal.

#### Impairment identification and management

- Upper Extremity and Trunk
  - ROM and strength
  - Limb volume
  - Activity limitations and performance restrictions
- Fatigue
- Pain
- Function
- Neuropathy
- Weight
- Bone Health and Arthralgias
- Cardiovascular/Pulmonary

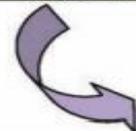
#### Health Promoting Skills and Behaviors

- Level of activity and function
- Education for ongoing detection of common treatment-related sequelae and maintenance of healthy lifestyle behaviors and weight management
- Exercise\*
  - Evaluation of activity limitations
  - Individualized exercise prescription
  - Referral to appropriate exercise program if needed



### Rehabilitation Intervention

If impairments are detected, initiate appropriate rehabilitation program; otherwise, continue interval surveillance.



\*A broad body of evidence supports exercise for patients with cancer. Cancer survivors are encouraged to exercise regardless of whether they are in a prospective model of care.

Figure 1. A prospective surveillance model for physical rehabilitation for women with breast cancer.

# Lymphedema: Early Detection Valuable, But Methods Debated

BY ROBERT H. CARLSON



**Cheville said she would not consider the model a guideline, since it has not undergone the critiques and rigorous scrutiny of a guidelines, and lacks evidence-based, validated algorithms. “These things should be evidence-based.**

**A basic tenet of good medicine is to risk-stratify patients, identify their vulnerabilities, screen in an evidence-based fashion, and modulate our monitoring and treatment responses over time.**

...ects of breast cancer treatment came out of a recent roundtable meeting sponsored by the American Cancer Society. More than a dozen international experts drafted the “Prospective Model of Care for Breast Cancer Rehabilitation,” which was published earlier this year in *Cancer* (2012;118 suppl 8:2191-2200).

There was less than perfect consensus, however, and two of the paper’s authors debated the recommendations in a session here at the most recent National Lymphedema Network Conference, a meeting jointly sponsored by the National Lymphedema Network and the University of Chicago Pritzker School of Medicine.

The paper’s first author, Nicole L. Stout, MPT, a certified lymphedema therapist, said the model needs to be the standard of care for women recovering



NICOLE L. STOUT, MPT, said the model needs to be the standard of care for women recovering from breast cancer.



ANDREA CHEVILLE, MD, argued that the model is too vague to implement and that any recommendations need to be evidence-based.

There has been less than perfect consensus about a possible model for surveillance and early detection of lymphedema and other debilitating side

# Early Stage : STAGE 0 and 1

- The latent stage
- Before overt swelling
- Lymphedema-related symptom
  - Heaviness, tightness, firmness, pain, numbness, impaired mobility
    - Armer, Radina, Porock, & Culbertson, 2003; International Society of Lymphology [ISL], 2003

# Lymphedema-Related Symptoms

**Table 3. Lymphedema-Related Symptoms**

Lymphedema symptoms	All participants <i>N</i> =136	Women who received Information <i>n</i> =77	Women who did not receive information <i>n</i> =59	Women who underwent SLNB only <i>n</i> =34
Swelling*	39 (29%)	15 (19%)	24 (41%)	9 (26%)
Heaviness*	24 (18%)	8 (10%)	16 (27%)	3 (9%)
Impaired shoulder mobility*	32 (24%)	13 (17%)	19 (32%)	6 (18%)
Seroma formation*	28 (21%)	8 (10%)	20 (34%)	8 (24%)
Breast swelling*	25 (18%)	6 (8%)	19 (32%)	7 (21%)
Firmness/tightness	47 (35%)	22 (29%)	25 (42%)	13 (38%)
Numbness	52 (38%)	29 (38%)	23 (39%)	12 (35%)
Tenderness	69 (51%)	37 (48%)	32 (54%)	17 (50%)
Aching	44 (32%)	23 (30%)	21 (36%)	8 (24%)
Stiffness	48 (35%)	22 (29%)	26 (44%)	11 (32%)
Arm weakness	28 (21%)	16 (21%)	12 (20%)	3 (9%)

*Note.* \*Chi-square or Fisher's exact test  $p < 0.05$  between participants who received information and those who did not.

다음 부위의 <b>붓춤</b> 움직임에 제한이 있습니까?	중증도				
	없다	약간	보통 정도	상당히	매우 심하다
1. 어깨	0	1	2	3	4
2. 팔꿈치	0	1	2	3	4
3. 팔목	0	1	2	3	4
4. 손가락	0	1	2	3	4
5. 팔	0	1	2	3	4

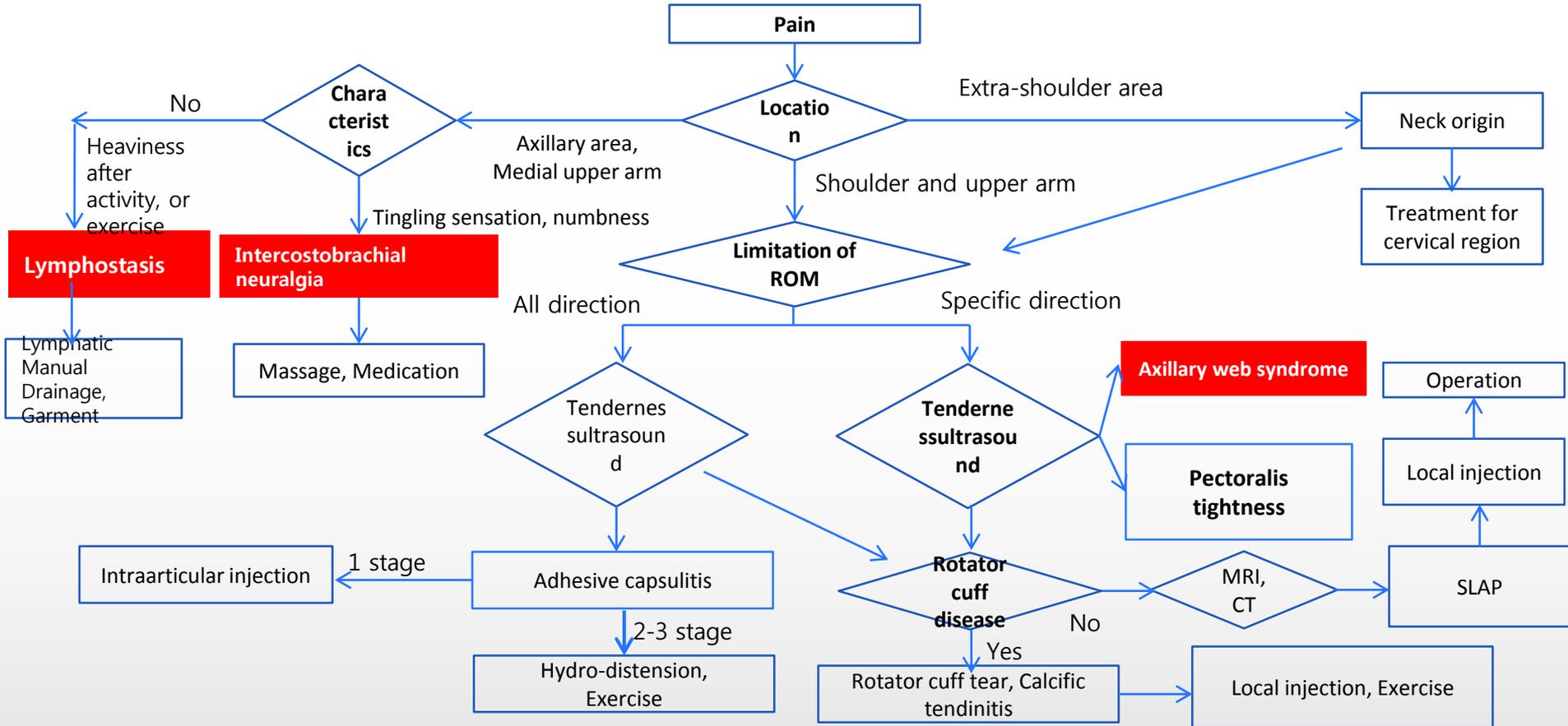
※다음 질문은 지난 3개월 동안 귀하의 **붓춤** 손이나 팔, 가슴, 겨드랑이(팔 밑), 가슴에 발생한 증상에 관한 것입니다.

다음 증상이 있습니까?	중증도				
	없다	약간	보통 정도	상당히	매우 심하다
6. 팔 또는 손의 부종	0	1	2	3	4
7. 윗방의 부종	0	1	2	3	4
8. 흉벽(가슴벽) 부종	0	1	2	3	4
9. 단단해짐	0	1	2	3	4
10. 당기는 느낌	0	1	2	3	4
11. 무거운 느낌	0	1	2	3	4
12. 피부가 거칠어지거나 두꺼워짐	0	1	2	3	4
14. 눌렀을 때 통증	0	1	2	3	4
15. 열감	0	1	2	3	4
16. 붉스레함	0	1	2	3	4
17. 물집	0	1	2	3	4
18. 통증	0	1	2	3	4
20. 회전거리며 따가움	0	1	2	3	4
21. 칼로 찌르는 듯함	0	1	2	3	4
22. 저린감(편이나 바늘로 찌르는 느낌)	0	1	2	3	4
23. 손이나 팔의 피로감	0	1	2	3	4
24. 손이나 팔의 근력 약화	0	1	2	3	4

# Differential Diagnosis

	Intercostobrachial neuralgia	Lymphostasis	Axillary web syndrome
<b>Location</b>			
<b>Characteristics</b>	<p>Resting pain Numbness Tinging sensation</p>	<p>After activity or exercise Heaviness Edema, Tightness</p>	<p>presence of taut, palpable cords originating in the axilla and extending distally along the anterior surface of the arm</p>
<b>Treatment</b>	<p>Medication (gabapentin, capsaicin cream) Massage</p>	<p>Complex decongestive treatment : Manual drainage massage : Garment</p>	<p>Fascia releasing Manual therapy</p>

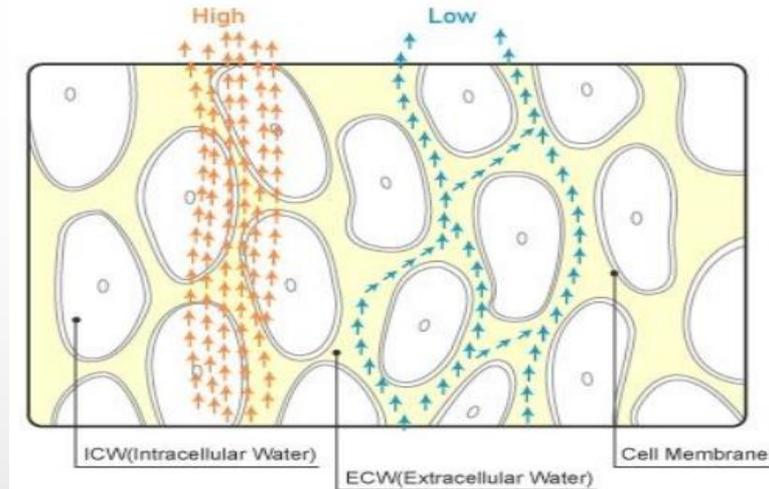
# Treatment related upper limb dysfunction of breast cancer



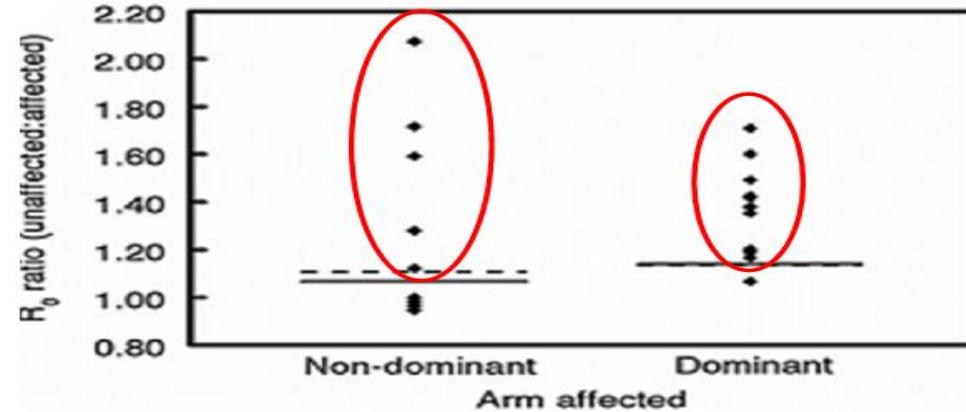
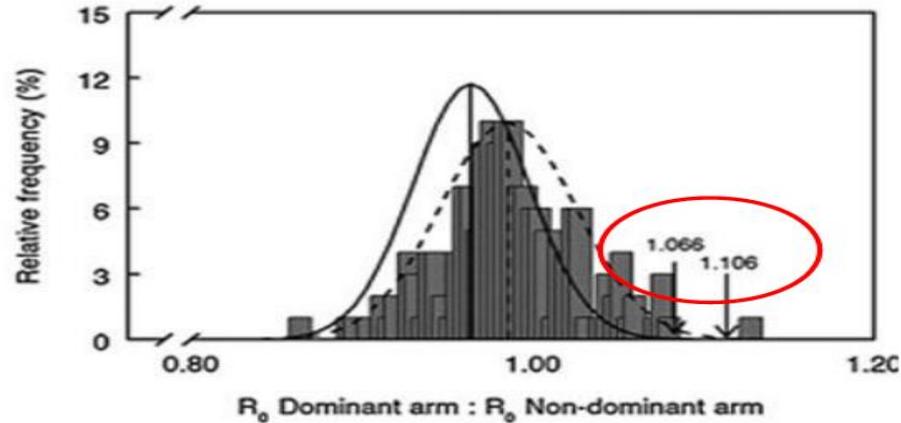
# Bioimpedance Measure

- Measuring the impedance to electrical current flow that passes through the body  
→ calculates the fluid volume indirectly

- $Vol \propto 1/Z$  (Impedance)
- At **low frequency**, current flows through **extra cellular water(ECW)**



# Bioimpedance Measure

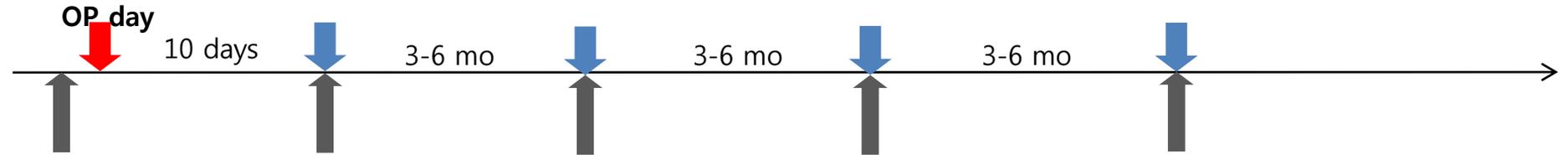


- Useful method for detecting lymphedema
- Indicative of early lymphedema
- The inter-limb ECF ratio
  - cut-offs for the presence of swelling
  - **a ratio  $\geq 1.139$**  for women in whom the surgery was on their dominant side
  - **a ratio  $\geq 1.066$**  for those in whom the surgery was on the non-dominant side

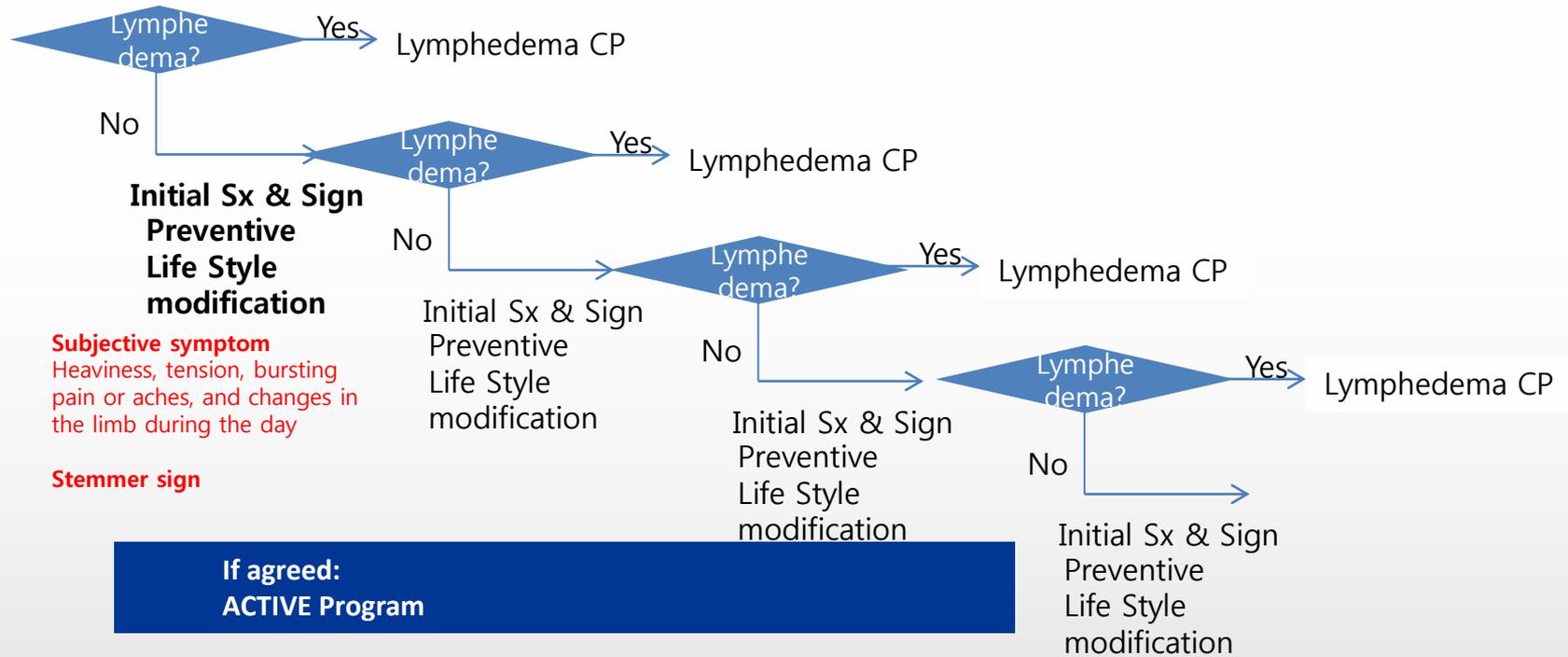
Cornish, et al. 2001

- Ward LC, (2011) Lymphat Res Biol 9(1):47–51

# Surveillance Protocol for Patients with High Risk of Lymphedema



**Dominant**  
ratio >1.066  
**Non dominant**  
ratio >1.106



**Subjective symptom**  
Heaviness, tension, bursting pain or aches, and changes in the limb during the day

**Stemmer sign**

**If agreed:  
ACTIVE Program**

# Risk Factor of Lymphedema

→ [www.lymphedemarisik.com](http://www.lymphedemarisik.com)



Cleveland Clinic



## Upper Limb Lymphedema after Axillary Lymph Node Dissection

Also visit the Arm Volume Calculator at [www.armvolume.com](http://www.armvolume.com)

Patient's age	<input type="text"/>	?
Patient's weight (Kg)?	<input type="text"/>	?
Patient's height (meter)?	<input type="text"/>	?
Number of cycles of neo- or adjuvant chemotherapy infusions in ipsilateral arm	<input type="text"/>	?
Please check here if you have both information about level of axillary dissection and the need of radiotherapy.	<input checked="" type="checkbox"/>	?
What is the level of axillary dissection?	I, II and III ▾	?
What is the planned radiotherapy field?	Breast or Chest Wall is needed ▾	?
Please check here if you have both information after 6 month from surgery about the development of seroma and early edema.	<input checked="" type="checkbox"/>	?
Did the patient develop seroma within 6 months from surgery?	No ▾	?
Did the patient develop arm edema within 6 months from surgery?	No ▾	?

Save Inputs Recall Inputs Clear Cache ?

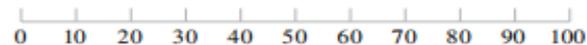
Calculate

Predicted 5-year lymphedema probability (%)

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<sup>1</sup> [Bevilacqua JL et al. Nomograms for Predicting the Risk of Arm Lymphedema After Axillary Dissection in Breast Cancer. Ann Surg Oncol. 2012 Aug;19\(8\):2580-9, DOI:10.1245/s10434-012-2290-x](#)

Points



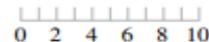
Age



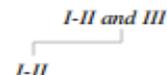
BMI



# of cycles of neoadjuvant chemotherapy



Level of axillary dissection

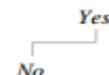


Radiotherapy field

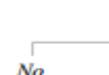
No RXT or breast or chest wall

Include lymph node basin

Seroma



Early Edema



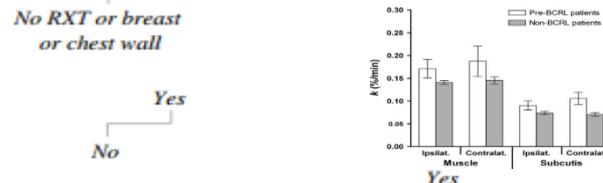
Total points



Predicted 5-year lymphedema probability



## High Filtering patients



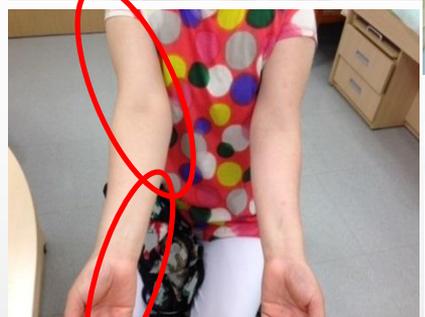
# 1<sup>st</sup> visit

## Self-check

Intercostobrachial neuralgia



Lymphedema



검사결과조회

진재결과 내진료과 내오더 Compare PACS Viewer 화면확장

1주 2주 1달 3달 6달 1년 3년 현재 선택 16410316

검사명 림프부종평가(체성분) 검사일자 2013-09-09 결과

1. General information

체중	61	기초태사량	1303
체지방	17.8	체수분	31.6
체지방률	29.2	육부지방률	.84
근육량	40.7	골격근량	23.8
BMI	23.4		

2. Calculated data

1) ECW/TBW

상지 (Rt)	.37	(Lt)	.37
하지 (Rt)	.37	(Lt)	.38

2) 1kHz임피던스

상지 (Rt)	427.4	(Lt)	432.1
하지 (Rt)	308	(Lt)	314.9

3) 5kHz임피던스

상지 (Rt)	417.1	(Lt)	423.2
하지 (Rt)	299.3	(Lt)	305.2

3. Calculated ratio

Rt upper limb			
ECF ratio	1.02		
1kHz SFBIA ratio	1.01		
5kHz SFBIA ratio	1.01		
Lt upper limb			
ECF ratio	.98		
1kHz SFBIA ratio	.99		
5kHz SFBIA ratio	.99		

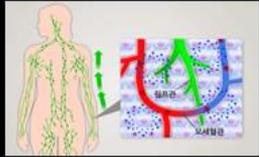
관독결과 결과이미지

PACS 100%

# 2<sup>ND</sup> visit

## 운동의 효과

• <http://hichart.tv/aFc>



운동 중 림프액 흐름 속도  
약 15배 ↑ (B. R. Lasinski, 1995)

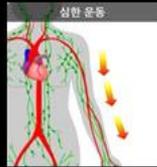
고감신경계의 지배를 받는 림프관의 수축을 자극  
(Witte and Witte, 1987)

집합 림프관(collecting lymphatics) 펌핑 작용 강화

## 운동의 모순



▪ 림프액의 이동에 도움



▪ 해당조직에 흐르는 혈액 양  
림프액도 더 많이 생성

## 운동의 방법



점진적이고 연속적인 강화 훈련 프로그램

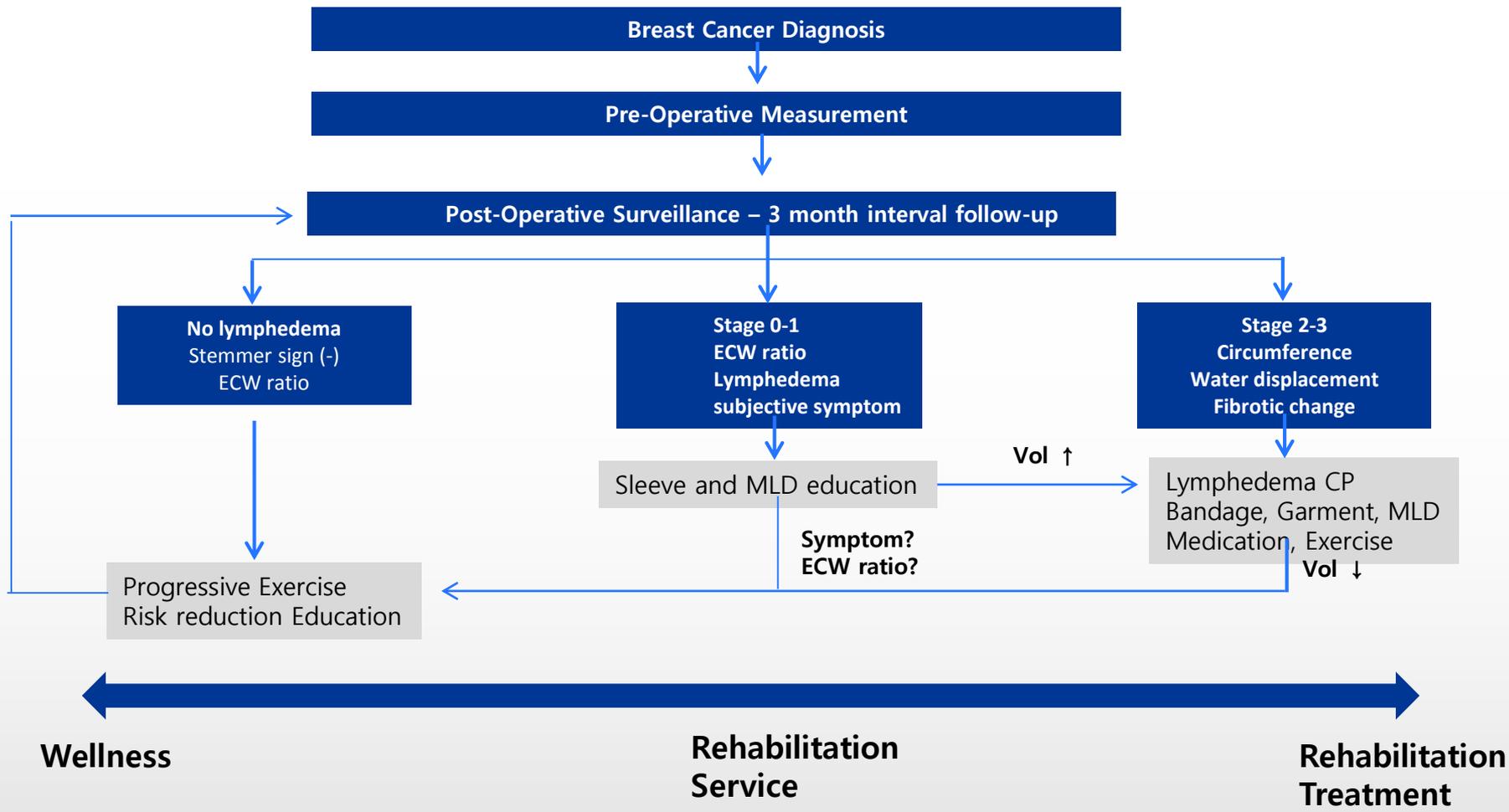
→ 어깨 주변과 팔 아래 부위의 남은 림프경로를 확

→ 림프부종의 발생 가능성을 최소화

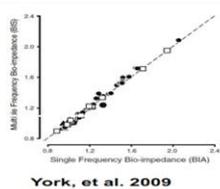
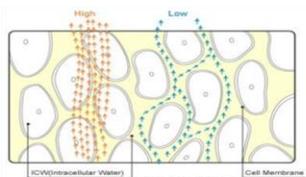


Smedley III Digital Grip Strength Dynamometer

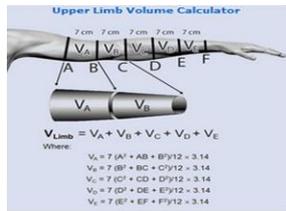
# Clinical Pathway for the Prospective Rehabilitation Model of Care



# Stage 0,1 Extra cellular water(ECW)



# Stage 2 Volume (cc)



# Stage 3 Structure (fibrotic change)



재화이하기 (기변) 리프 보조 펌가 과도지

Rt upper limb

ECF ratio	1.02
1kHz SFBIA ratio	1.01
5kHz SFBIA ratio	1.01

Affected side Right  
Lymphedema measure  
1) Circumference (cm)  
Affected upper limb circumference

(U) 14 cm	29	volume
(U) 7 cm	25	407.03
antecubital crease	24.5	341.41
(L) 7 cm	24.2	330.45
(L) 14 cm	20	273.02
(L) 21 cm	15	171.84

Unaffected upper limb circumference

(U) 14 cm	27.5	volume
(U) 7 cm	24	370.11
antecubital crease	23	307.83
(L) 7 cm	21	269.93
(L) 14 cm	17	201.94
(L) 21 cm	15	142.86

2) Volume

from volume calculator	(U)	(L)
Affected limb volume (ml)	1523.75	
Unaffected limb volume (ml)	1292.67	
Volume difference (ml)	231.08	

검사명	Sono OBGY( OPD ) 1st	검사일자	2015-10-16	결과	시행
	림프부종평가(추적)		2015-09-17		관독

Water displacement

	Pre(cm)	Post(cm)	Volume (cm^3)
Affected	15	7	1413.72
Intact	15	8.2	1201.66

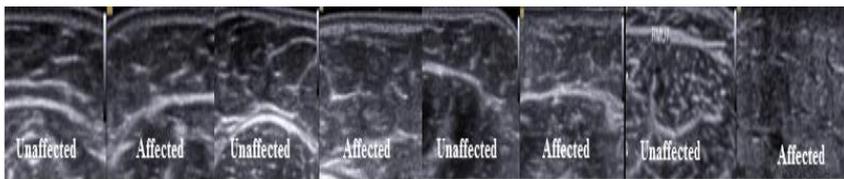
3) USG (upper limb subcutaneous echogenicity grade)

Affected (medial)	
(U) 14 cm (routine)	0
(U) 7 cm (routine)	0
antecubital crease	
(L) 7 cm (routine)	1
(L) 14 cm (routine)	1
(L) 21 cm	
Unaffected (medial)	
(U) 14 cm (routine)	0
(U) 7 cm (routine)	0
antecubital crease	
(L) 7 cm (routine)	0
(L) 14 cm (routine)	0
(L) 21 cm	
Affected (lateral)	
(U) 14 cm (routine)	

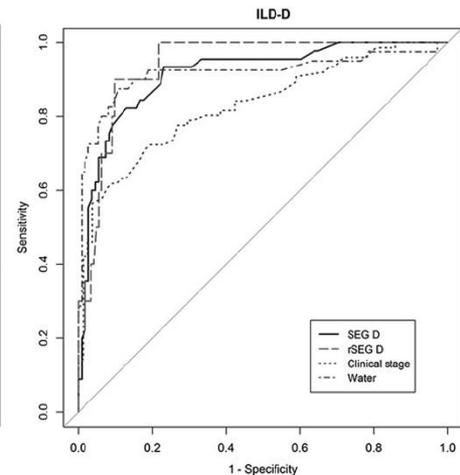
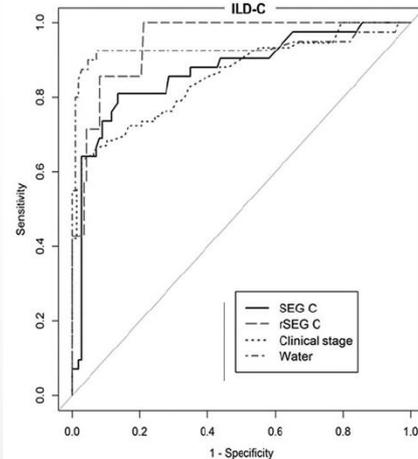
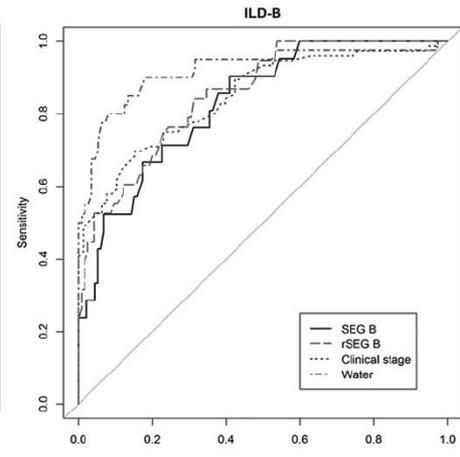
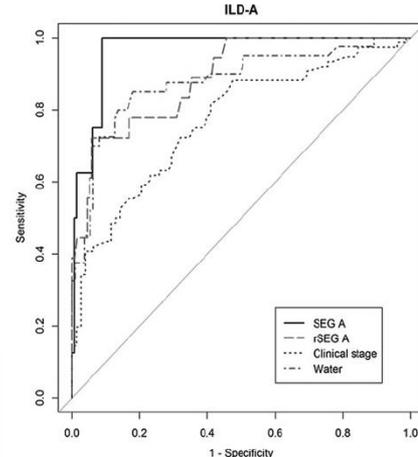


# Diagnostic Accuracy of Clinical Measures Considering Segmental Tissue Composition and Volume Changes of Breast Cancer-Related Lymphedema

Eun Joo Yang, MD, PhD<sup>1</sup>, Seoung Yeon Kim, MD<sup>2</sup>, Woo Hyung Lee, MD<sup>2</sup>,  
 Jae-Young Lim, MD, PhD<sup>1</sup>, and Jaebong Lee, MS<sup>2,3</sup>



SEG	0	1		2
Echogenicity	Low	Increased		Increased
Echogenic lines	Clear	Unclear but identifiable		Unidentifiable
rSEG	0	1	2	3
Echogenicity	Low	Increased	Increased	Increased
Echogenic lines	Clear	Clear	Unclear but identifiable	Unidentifiable

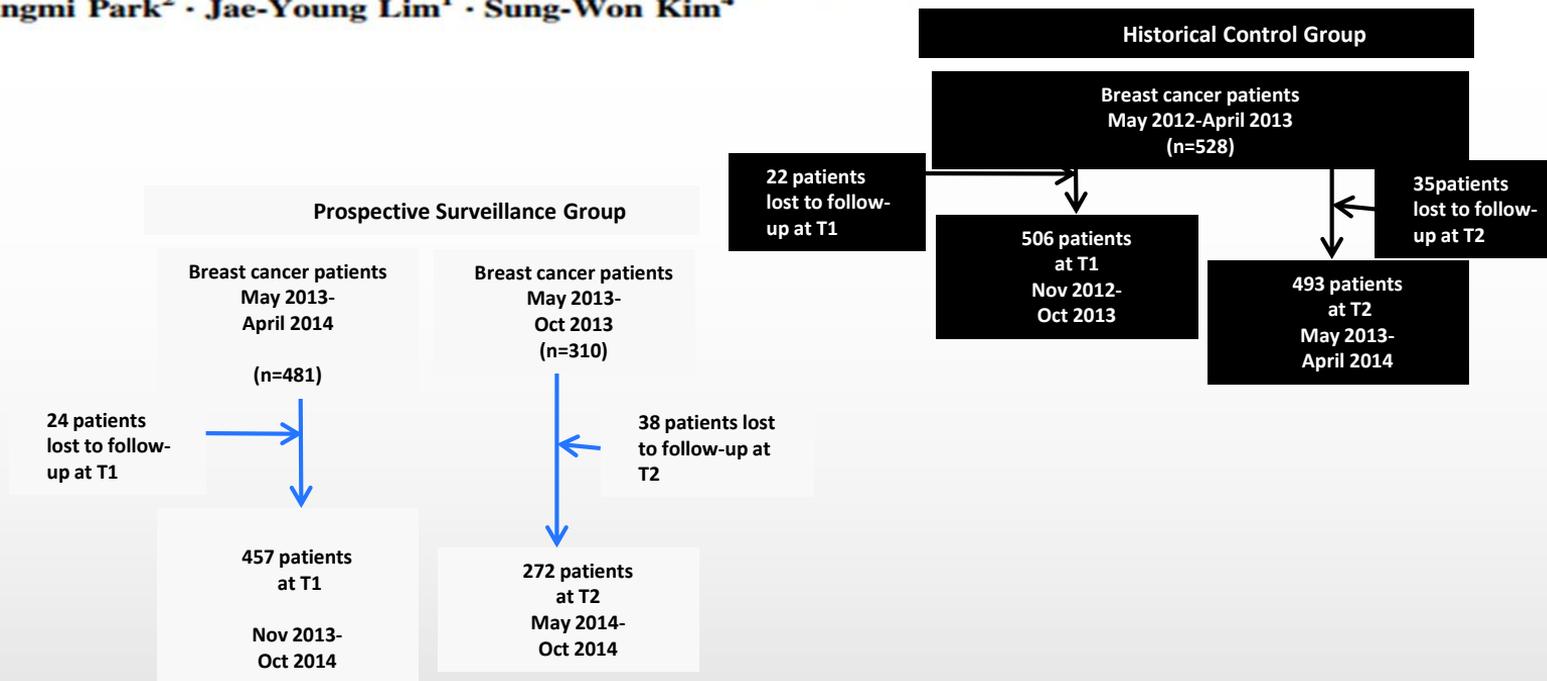


ROC curve of segmental volume and lymphedema measurement tools

CLINICAL TRIAL

# Use of a prospective surveillance model to prevent breast cancer treatment-related lymphedema: a single-center experience

Eun Joo Yang<sup>1</sup> · Soyeon Ahn<sup>2</sup> · Eun-Kyu Kim<sup>3</sup> · Eunyoung Kang<sup>3</sup> ·  
Youngmi Park<sup>2</sup> · Jae-Young Lim<sup>1</sup> · Sung-Won Kim<sup>4</sup>



# Results

	HC group ( <i>N</i> = 317), <i>n</i> (%)	SLYM group, ( <i>N</i> = 390), <i>n</i> (%)
Age at diagnosis (years)	48.6 ± 11.7 (25–82)	47.6 ± 10.7 (23–89)
BMI	23.3 ± 9.8	24.3 ± 9.5
Dominant side	132 (41.6 %)	207 (53.0 %)
Histopathologic stage		
I (%)	92 (29.0 %)	109 (28.0 %)
II (%)	168 (53.0 %)	215 (55.0 %)
III (%)	57 (18.0 %)	66 (17.0 %)
Breast surgery		
BCS	28 (8.8 %)	138 (35.4 %)
Mastectomy	289 (91.1 %)	252 (64.6 %)
Radiotherapy		
Not done	41 (12.9 %)	47 (12.0 %)
Breast only	174 (54.9 %)	211 (54.0 %)
Breast and SCRT (%)	102 (32.2 %)	140 (36.0 %)
Chemotherapy		
Doxetaxel	223 (70.3 %)	280 (71.9 %)
Cycle of doxetaxel	5.1 ± 0.3	6.1 ± 0.2

HC historical control, SLYM surveillance program for lymphedema management, BCS breast-conserving surgery, SCRT supraclavicular radiation therapy

**Table 2** Multivariate analysis of risk factors associated with lymphedema (*N* = 707)

Clinical characteristics	HR	95 % CI	<i>P</i> value <sup>a</sup>
Age (≥60 years)	0.03	0.01–0.05	0.014
BMI (≥25 kg/m <sup>2</sup> )	1.60	0.69–2.75	0.255
Dominant side	1.75	0.45–8.63	0.432
Histopathologic stage (≥II)	1.52	0.73–3.11	0.321
Type of surgery (mastectomy)	1.17	0.42–3.29	0.766
Radiation therapy (breast with SCRT)	2.01	1.05–3.03	0.045
Chemotherapy (taxel)	4.98	1.93–12.87	0.001
Surveillance protocol	0.31	0.17–0.56	<0.001

HR hazard ratio, CI confidence interval, SCRT supraclavicular radiation therapy

<sup>a</sup> Cox proportional hazards model

## Risk factor of lymphedema

ALND

Age

Radiation therapy on SCRT

Chemotherapy with taxel



Surveillance

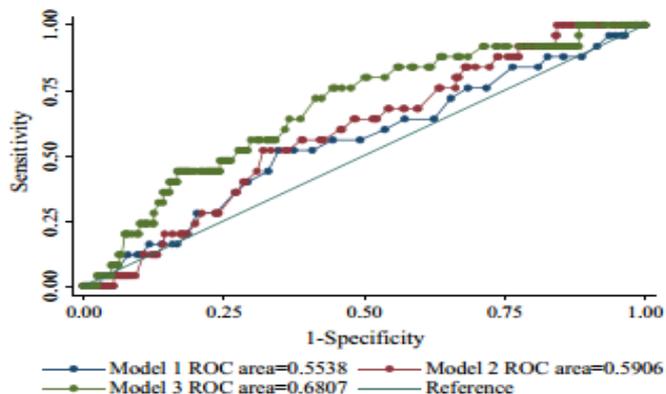
**Table 3** Multiple logistic regression analysis of patients with breast cancer in surveillance group ( $N = 390$ )

Variables	Model 1	Model 2	Model 3
Age	1.01 (0.98–1.05)	1.01 (0.98–1.05)	1.02 (0.98–1.05)
BMI	1.02 (0.97–1.06)	1.02 (0.97–1.05)	1.03 (0.98–1.05)
Dominant side	1.05 (0.96–1.16)	1.06 (0.96–1.16)	1.06 (0.97–1.15)
Type of surgery (mastectomy)		1.70 (0.86–6.55)	1.67 (0.88–6.11)
Radiation therapy (breast with SCRT)		2.02 (1.06–3.11)*	2.01 (1.05–3.10)*
Chemotherapy (taxel)		5.56 (2.00–9.11)*	5.55 (1.99–9.01)*
Poor compliance (interval of follow-up >3 months)			3.16 (1.36–6.89)*
Low grade of self-monitoring and insight (score $\leq 2$ )			1.31 (1.03–3.24)*

Values are odds ratio (95 % CI)

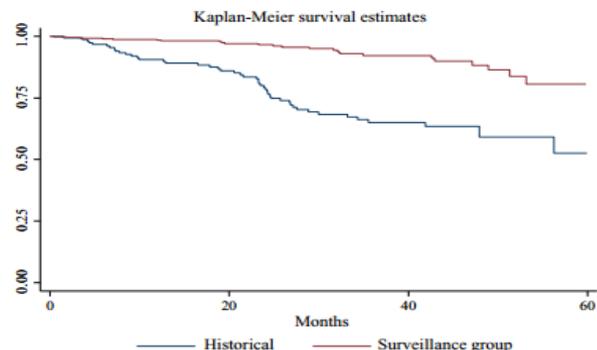
Model 1: Age, BMI, and dominant side

Model 2: Model 1 + histopathologic stage, type of surgery, radiation therapy, chemotherapy

**Fig. 2** ROC curve of lymphedema prediction in surveillance group**Fig. 1** Kaplan–Meier with log-rank analysis for the irreversible lymphedema in the surveillance group compared the historical control group

Supplemental table 1

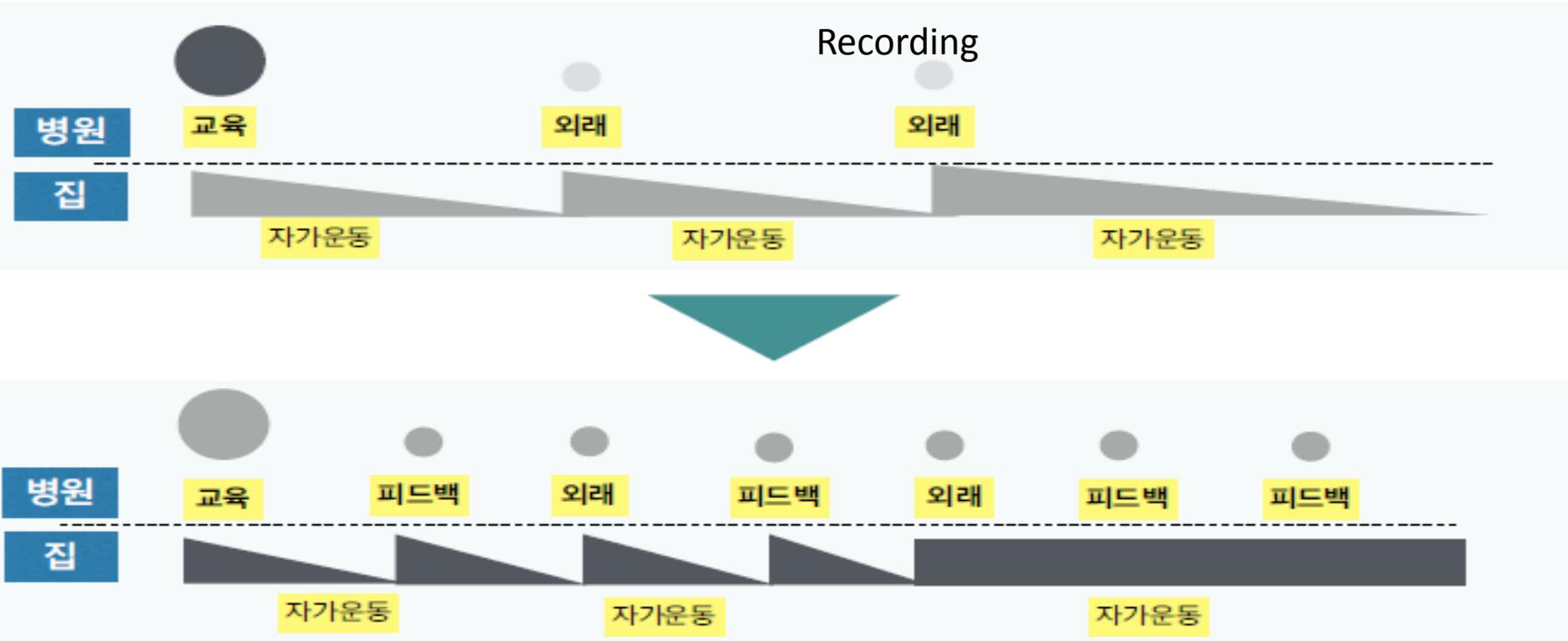
Cut-off value (day) <sup>a</sup>	sensitivities <sup>b</sup>	specificities <sup>c</sup>
1.5	1 <sup>d</sup>	0.00 <sup>e</sup>
4.0	1 <sup>d</sup>	0.02 <sup>e</sup>
5.5	1 <sup>d</sup>	0.03 <sup>e</sup>
6.5	1 <sup>d</sup>	0.04 <sup>e</sup>
7.5	1 <sup>d</sup>	0.05 <sup>e</sup>
8.5	1 <sup>d</sup>	0.08 <sup>e</sup>
9.5	1 <sup>d</sup>	0.09 <sup>e</sup>
10.5	0.96 <sup>d</sup>	0.13 <sup>e</sup>
11.5	0.92 <sup>d</sup>	0.20 <sup>e</sup>
12.5	0.92 <sup>d</sup>	0.22 <sup>e</sup>
13.5	0.8 <sup>d</sup>	0.33 <sup>e</sup>
14.5	0.8 <sup>d</sup>	0.36 <sup>e</sup>
15.5	0.8 <sup>d</sup>	0.38 <sup>e</sup>
16.5	0.8 <sup>d</sup>	0.40 <sup>e</sup>
17.5	0.8 <sup>d</sup>	0.43 <sup>e</sup>
18.5	0.8 <sup>d</sup>	0.47 <sup>e</sup>
19.5	0.8 <sup>d</sup>	0.47 <sup>e</sup>
20.5	0.72 <sup>d</sup>	0.51 <sup>e</sup>
21.5	0.68 <sup>d</sup>	0.52 <sup>e</sup>
22.5	0.68 <sup>d</sup>	0.53 <sup>e</sup>
23.5	0.68 <sup>d</sup>	0.54 <sup>e</sup>
24.5	0.68 <sup>d</sup>	0.55 <sup>e</sup>
25.5	0.64 <sup>d</sup>	0.57 <sup>e</sup>
26.5	0.64 <sup>d</sup>	0.57 <sup>e</sup>
27.5	0.6 <sup>d</sup>	0.59 <sup>e</sup>
28.5	0.6 <sup>d</sup>	0.60 <sup>e</sup>
29.5	0.6 <sup>d</sup>	0.61 <sup>e</sup>
31.0	0.56 <sup>d</sup>	0.62 <sup>e</sup>
32.5	0.56 <sup>d</sup>	0.62 <sup>e</sup>
33.5	0.56 <sup>d</sup>	0.62 <sup>e</sup>
34.5	0.56 <sup>d</sup>	0.63 <sup>e</sup>
36.0	0.52 <sup>d</sup>	0.65 <sup>e</sup>
37.5	0.52 <sup>d</sup>	0.66 <sup>e</sup>



N at risk	12 mo	24 mo	36 mo	48 mo	60 mo
Surveillance	144	94	57	49	1
Probability (%)	97	93	89	80	80
Historical	119	85	47	18	2
Probability (%)	80	66	62	58	58

## 1-4. Service Paradigm Shift by IoTed Self-Rehab

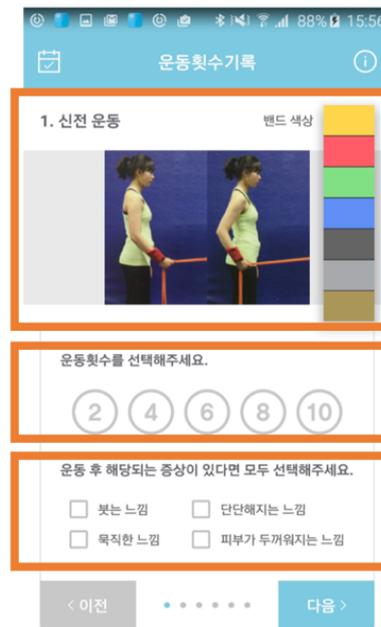
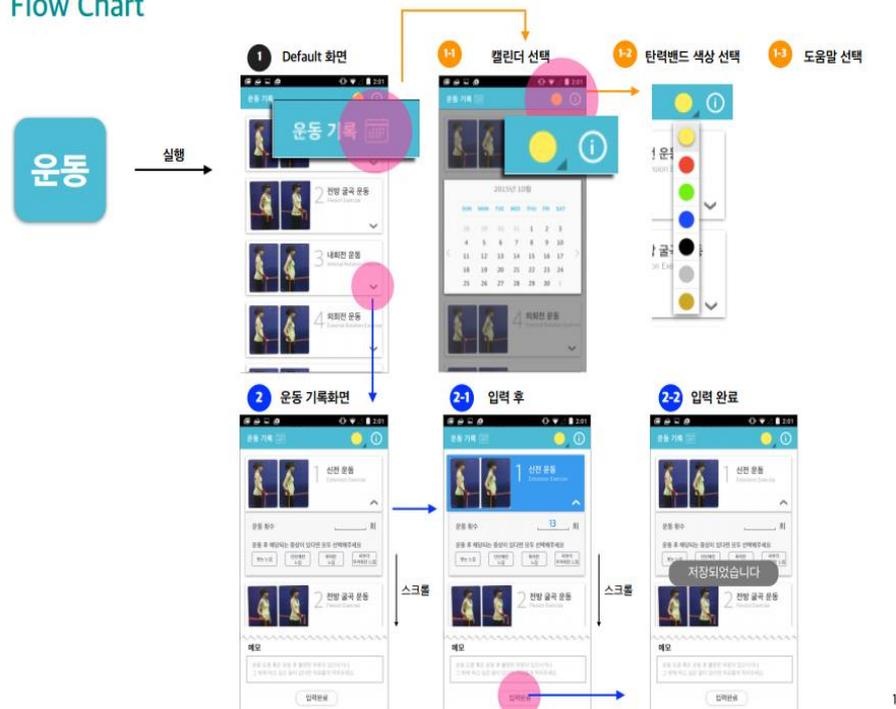
재활 치료에서의 중요도 ● ● ● 순





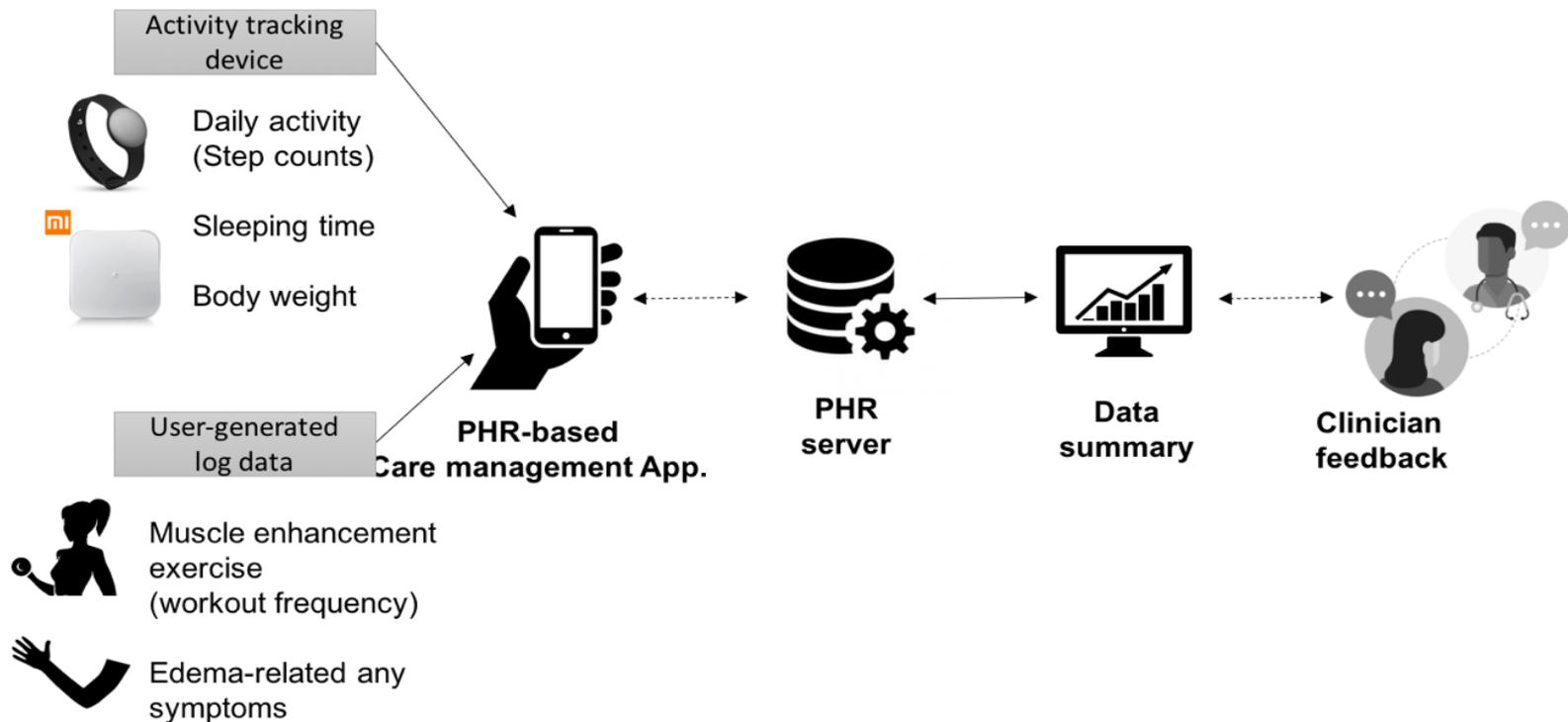
# Application of exercise for breast cancer patients

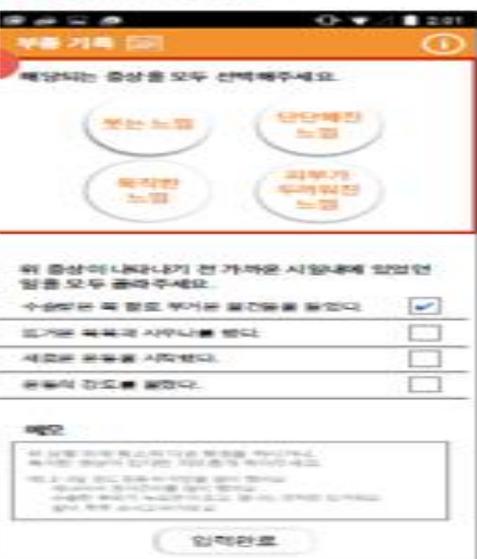
## Flow Chart



- The name of exercise
- Video material
- Exercised frequency
- Edema-related symptoms after the exercise

# PHR-based lymphedema care management





# P07 기본 인적정보

“ 평생 압박스타킹을 끼고 살 순 없잖아요. 열심히 운동할거예요.”

”

- 병기 : 3기 C
- 수술경과 : 7개월
- 실험 전 부종경험 여부 : Yes

- 연령 : 만 40세
- 직업 : 주부
- 거주형태 : 가족과 거주
- 가족 : 남편, 자녀 1명
- 키 : 161.7
- 몸무게 : 46kg
- BMI : 17.6

## 데이터 특성

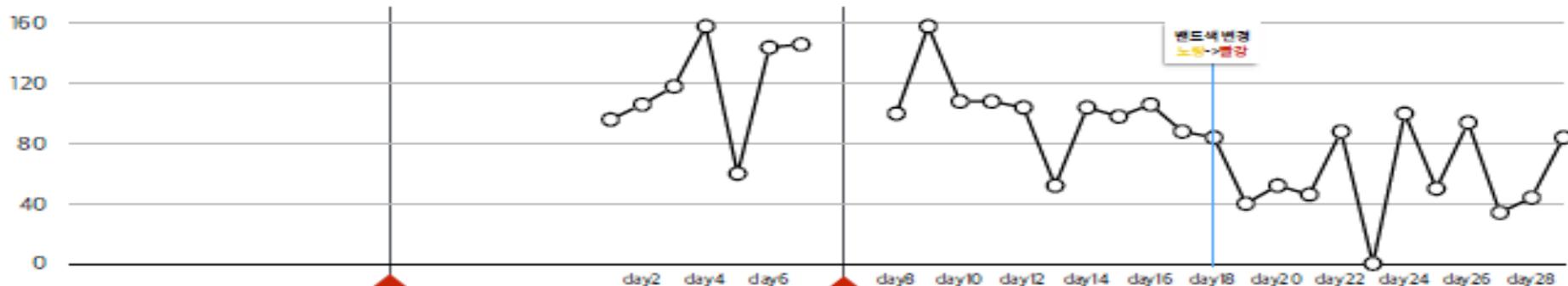


- 전체 데이터 수집률 : 98.3%
- 근력운동 : 96.6%
- 활동량 수집률 : 100%
- 수면 : 96.6%
- 체중 : 100%
- 전체 인터랙션 : 43건 (앱 메모, 밴드, 문자메시지 포함)

## 피험자 특성

- 앱 사용 만족도 : 4.3 / 5
- 실험 만족도 : 9 / 10
- 기계 친밀도 : 3.8 / 5
- 기술 수용도 : 2.8 / 5

## 일간 근력운동 횟수 (Thera-band)



### 실험 전

- 운동
- 운동처방을 받아 시행
- 부종
- 압박스타킹 착용
- 도자기 만드는일 그만둠
- 부종발생시 메모습관

### 실험시작

- 운동기록 앱
- 부종기록 앱 설치

### 1차 기록 (데이터 진료 전)

- 하루 평균 118번, 동작별로 20번
- 하루도 빼먹지 않고 실시
- 근력운동 시 부종증상 1회 나타남

### 데이터 진료

- 부종 가능성 있거나 힘든 운동의 결과로 횟수 줄일 것
- 5번에서 힘들면 4번~3번 할 것

### 2차 기록 (데이터 진료 후)

- 하루 평균 79번으로 줄임, 동작별로 10번
- 매일매일 꾸준히
- 밴드색을 노랑 -> 빨강으로 바꿈(스스로 운동강도 상향조정)

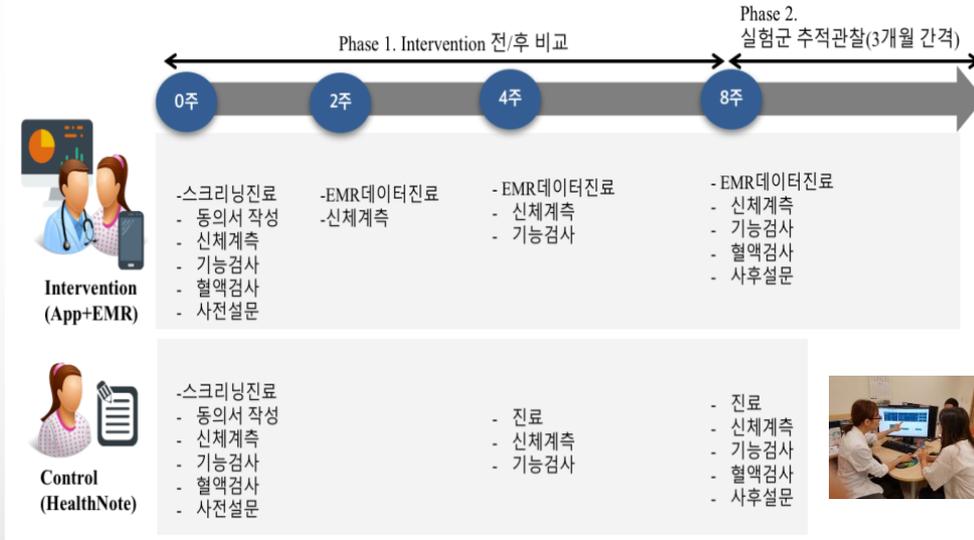
### 부가 및 총평

의료진 처방 적극이행 + 스스로 밴드 변경 및 운동량 조절

# Effects of the Personal Health Record based Healthcare Management Program on Self-Care Status in Patient with Breast Cancer with Lymphedema

▪ Eun Joo Yang, Borim Ryu<sup>1</sup>, Sooyoung Yoo<sup>1</sup>, Jeong-Whun Kim<sup>2</sup>

- The effect of PHR on the compliance of progressive resistance exercise with theraband was assessed by using a randomized controlled trial (RCT) protocol for a 2-arm parallel group with a 1:1 allocation ratio



Under review

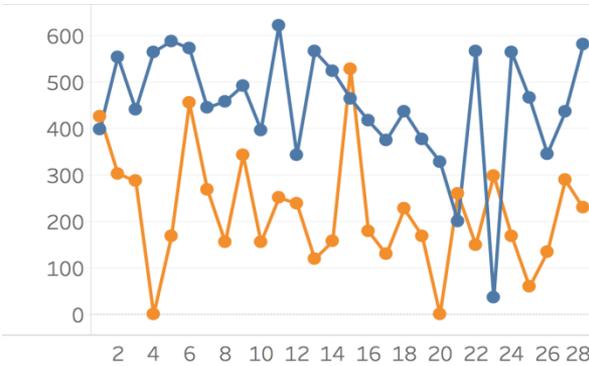


Fig. Change of the total number of resistance exercise divided by groups

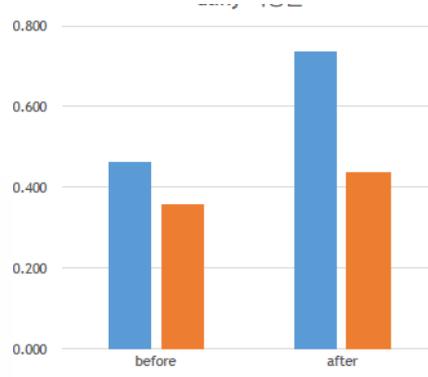
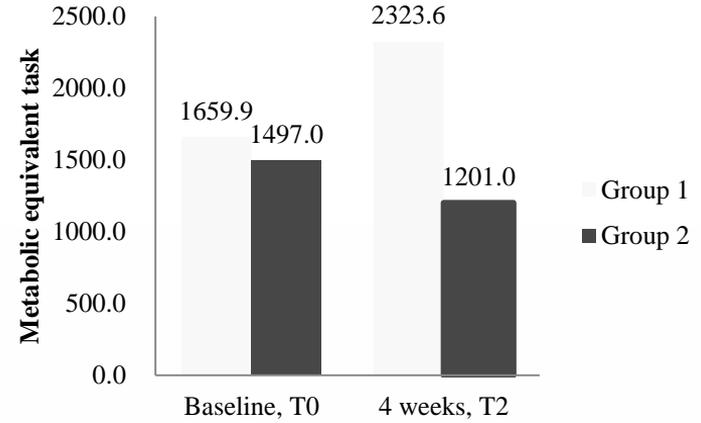


Fig. Comparison of compliance rate between two groups



Metabolic equivalent task score changes in subgroup analysis

Group 1: patients without symptom at baseline  
 Group 2: Patients who reported symptom after exercise before enrollment

The frequency of exercise (days per week) in the intervention group had a significant difference compared to the control group ( $4.2 \pm 1.5$  vs  $2.1 \pm 0.7$  days per week). Patients who reported symptom after exercise before enrollment had more improvement in the intervention group compared to the patients without symptom at baseline

# Closing

- Surveillance program for lymphedema
  - Physiology of lymphatic drainage
  - Early diagnosis of lymphedema
  - Conservative treatment with Surveillance program
- Real world management with IoT
  - Exercise program with ICT for high risk of lymphedema
  - Future step



**Thank you !**  
**For your attention**