Arm lymphoedema in a cohort of breast cancer survivors 10 years after diagnosis

KARIN JOHANSSON1 & ELIN BRANJE2

1Department of Health Science, Lund University, S-221 00 Lund, Sweden and 2Department of Oncology, Lund University Hospital, S-221 85 Lund, Sweden

Abstract

Introduction. Arm lymphoedema is a frequent complication after breast cancer treatment. Early diagnosis and treatment is considered important for successful management of breast cancer related arm lymphoedema (BCRL). The purpose was to identify BCRL incidence, time of onset, progression/regression and associated factors 10 years after breast cancer diagnosis. Material and methods. Two hundred and ninety two patients treated with axillary node dissection and radiotherapy were included in this retrospective study. A total of 111 diagnosed with BCRL (incidence 38.7%). Of these women 98 were followed for up to 10 years after BCRL diagnosis. Forty consecutive patients registered with no BCRL were included in the control group. BCRL was defined as an increase in arm volume difference ≥5% and an increased thickness of subcutis. Follow-up was performed twice a year, including assessment of lymphoedema relative volume (LRV) by water displacement method and compression treatment. Additional intensive treatment was given if LRV increased by more than 5% since the previous visit or exceeded 20% in total. Results. Mean LRV was 8.1±3.6% at diagnosis and 9.0±6.7% at last follow-up measurement (mean 48.9±39.2 months) with no significant difference. There was no difference in progression of LRV between groups with early versus late diagnosis after operation, small (5–10%) versus large (≥10%) LRV at time of diagnosis, or regular (at least twice a year) versus non-regular treatment. More BCRL patients with large LRV at diagnosis (15.8%), exceeded LRV ≥20% during follow-up time, than patients with small LRV at diagnosis (10.1%). Conclusion. BCRL can be identified at an early stage both in regard to time of diagnosis after operation and to edema volume, and that edema volume can be kept at a low level for at least 10 years. Small LRV at time of diagnosis appears to be more important for minimizing the progression of LRV than time of diagnosis after operation.

Every year about 7 000 new cases of breast cancer are diagnosed in Sweden, making it one of the most common cancer diagnoses among Swedish women. Although the incidence has steadily increased over the last couple of decades, the five year survival rate has also increased and is now 86% due to new diagnostic methods and better treatment of the disease [1]. An increase in the number of survivors gives rise to more patients with treatment-related side effects. One of these is breast cancer related arm lymphoedema (BCRL). The incidence of BCRL varies depending on methods of measuring the lymphoedema and different treatments for breast cancer. However, there is an increased risk (about 40% in Sweden) when treatment includes axillary dissection and post surgery radiotherapy to the breast and axilla [2,3]. In Sweden it has been estimated that 4 000–6 000 women have BCRL, with 800 new cases a year.

The lymphatic system consists of vessels that transport fluid and plasma proteins from interstitial tissue to the blood circulation. Lymphoedema occurs when the draining of lymphatic fluid ceases to work and fluids accumulate in the tissue. This leads to the development of swelling. Among the first symptoms of lymphoedema are a subjective sensation of tightness in the affected arm and a palpable increasing tightness of subcutis [4]. This condition may be reversible and effective treatment includes compression bandaging, wearing a sleeve/glove, manual lymphatic drainage and pneumatic pumping [5,6]. If the edema is allowed to progress without treatment the volume will increase [7], and the arm will get heavy and cause discomfort and pain. Hypertrophy of fat tissue may develop and eventually also fibrosis [8]. This condition is considered chronic and cannot be treated conservatively.
Psychosocial aspects have been examined in conjunction with lymphoedema, revealing depression, anxiety and impairments related to work, social and intimate relationships as well as problems with understanding of the chronic disease, including coping strategies [9]. Ridner [10] showed that even if the lymphoedema has been controlled breast cancer patients with lymphoedema report poorer quality of life than patients without lymphoedema. Taking both physical and psychosocial problems into account, early diagnosis and treatment of BCRL is important to minimize the development of lymphoedema.

Early identification of BCRL and early treatment has been more frequently recommended during the last few years based mostly on clinical experiences. However, a pilot study by Johansson et al. [11] of 69 patients with BCRL with a mean follow-up of 30 ± 10 months has shown that early diagnosis and treatment of BCRL may keep the arm volume on a low and steady level or even be reduced compared to the volume at time of diagnosis. These results were supported by Stout Gergich et al. [12] who found that subclinical BCRL could be effectively treated in 43 patients with only daily wearing of compression garments (20–30 mmHg) during about four weeks. The intervention was followed by recommendations of a more flexible approach of how and when to continue to use the garments. After an average of five months of the regime the results after intervention were still maintained.

Despite these findings, there is a lack of long-term follow-up examining the influence of factors associated with the progression of BCRL after diagnosis, such as time of diagnosis, amount of oedema volume at diagnosis and arm lymphoedema treatment. Therefore the purpose of this study was to identify the incidence of BCRL, time of onset, and associated factors of progression/regression 10 years after breast cancer diagnosis.

Research questions

- What is the incidence of BCRL during a 10-years period post surgery and when is the diagnosis?
- How does BCRL progress 1, 2, 4, 6, 8 and 10 years after the BCRL was diagnosed?
- Are there differences in BCRL progression between early and late BCRL diagnosis?
- Are there differences in BCRL progression between lymphoedema relative volume (LRV) <10% and LRV ≥10% LRV at BCRL diagnosis?
- Are there differences in BCRL progression between regular treatment and non-regular treatment after BCRL diagnosis?

Material and methods

This study was a retrospectively designed study with a nested case control analysis.

The study was approved by the Regional Ethics Committee, Lund, Dnr 105/2008.

Study population

The study population included breast cancer patients treated with unilateral axillary dissection (≥5 nodes) and radiotherapy to the breast and axilla. These patients had participated in routine follow-up monitoring of arm volume at least twice within one year since the end of primary medical treatment, from September 1995 to December 2006 at the Lymphoedema Unit, Lund University Hospital, Sweden.

Arm lymphoedema was defined as an increase in LRV of at least 5% and palpated increased skin and subcutis thickness compared to the non-operated arm [13].

Patients previously diagnosed with lymphoedema or with concurrent diseases that may affect the development of an arm lymphoedema were excluded. Patients with prior history of contralateral breast cancer or of severe orthopedic or neurological injury to either extremity were also excluded. Data from patients with BCRL and recurrent cancer were included until one year before the recurrence was detected. Patients who withdrew from the study were followed until time of withdrawal.

Patients. Data was collected retrospectively from the patients’ records. Two hundred and ninety two patients, were included in the study and 111 were diagnosed with BCRL (38.7%) during the follow-up period. Two of the BCRL patients had preoperative BCRL and 11 patients had recurrence in their cancer disease within one year after BCRL diagnosis. Characteristics of the remaining 98 patients are presented in Table I. Forty-two patients were not measured regularly twice a year, in which case the last measurement performed was used. The patients were stratified into sub groups and definition of these groups can be found in Table II.

Controls. The controls (n=40) were consecutively included from the group who had not been diagnosed with BCRL (n=181) at Lund University Hospital during the follow-up period. Controls were defined as those individuals determined to have no BCRL in at least two measurements within the one year following the end of their primary medical treatment for breast cancer. No further follow-up was completed on these individuals until measurements were performed for study outcome assessment close
The method has been described which is used as the gold standard of limb volume measurements [14]. The method was the water displacement method (Archimedes principle) for limb volume measurement. Arm volume was measured with the water displacement method and 3164 ± 789 ml by CLEMS with no significant difference and a high correlation coefficient (r = 0.992). Further, they measured plaster figures and demonstrated that CLEMS had a high test-retest correlation (r = 0.999).

In the Lymphoedema Unit, a cylindrical container with a soft drain pipe 45 cm above bottom was filled with water. Each arm was submerged in a straight position with the fist resting with the proximal phalanges at the bottom (Figure 1). The displaced water was collected in a tank and weighed in grams with a precision of 1 g and translated into millilitre (assuming water has a density of 1 g/ml). The contralateral arm was used as control at each occasion.

The lymphoedema absolute volume (LAV) was obtained by calculating the difference in volume between the arm on the treated side and the contralateral arm. The lymphoedema relative volume (LRV) was calculated using the following formula:

\[
\text{LRV} = \frac{\text{Vol. arm treated side} - \text{vol. contralateral arm}}{\text{vol. contralateral arm}} \times 100
\]

By using this formula, differences in build and body shape is taken into account. The use of the contralateral arm acts as a control and the relative volume increase can be calculated. Two people with the same LAV will have different LRV depending on if they are overweight, with a fat untreated arm, or if the untreated arm is slender.

### Measurements

**Arm volume.** Arm volume was measured with the water displacement method (Archimedes principle) which is used as the gold standard of limb volume measurements [14]. The method has been described by Kettle [15] who found a standard deviation of 1.5% from the mean volume of repeated measurements. Bednarczyk et al. [16] carried out a validity test for the water displacement method with a computerised limb volume measurement system (CLEMS). Eighteen legs were measured with both methods showing mean volume 3177 ± 844 ml determined by water displacement method and 3164 ± 789 ml by CLEMS with no significant difference and a high correlation coefficient (r = 0.992). Further, they measured plaster figures and demonstrated that CLEMS had a high test-retest correlation (r = 0.999).

Table II. Definition of the sub groups with breast cancer related arm lymphoedema.

<table>
<thead>
<tr>
<th>Sub group</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Early BCRL</td>
<td>arm lymphoedema diagnosed ≤ 12 months after operation. Patients with early BCRL had all been diagnosed within the routine follow-up.</td>
</tr>
<tr>
<td>Late BCRL</td>
<td>arm lymphoedema diagnosed &gt;12 months after operation. Patients with late BCRL had either contacted the Lymphoedema Unit themselves or been referred by a physician.</td>
</tr>
<tr>
<td>Small LRV</td>
<td>LRV ≤ 10.0% at time of diagnosis.</td>
</tr>
<tr>
<td>Large LRV</td>
<td>LRV &gt;10.0% at time of diagnosis.</td>
</tr>
<tr>
<td>Regular treatment</td>
<td>was defined as treatment at least twice a year with at least two compression sleeves.</td>
</tr>
<tr>
<td>Non-regular treatment</td>
<td>was defined as treatment frequency less than twice a year or with longer intervals by the patient’s choice.</td>
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Palpation of skin and subcutis thickness. Increased skin and subcutis thickness can be palpated if the tissues are pinched between finger and thumb. The palpation is performed simultaneously in the medial part of the operated and non-operated arm (Figure 2).

A pilot study has been performed in order to evaluate the inter-rater reliability of palpation of skin thickness in the medial part of the arm in breast cancer treated women. One physiotherapist with extensive experience and two with limited experience estimated the thickness of the skin and subcutis in 10 patients with axillary dissection performed at least one month earlier. The agreement between the experienced physiotherapist and those with limited experience was good, showing a kappa value of 0.78 for the upper arm and 0.80 for the forearm (same value for both PTs) (data not published).

Procedures

BCRL patients. At time of diagnosis all patients were provided with an arm sleeve (compression class II) and advised to care for the skin, to put the arm in an high position during longer resting periods, to regularly perform pumping exercise with the whole arm, to avoid very heavy and monotonous work, and to do self-massage.

Follow-up was performed twice a year, and included assessment of LRV, weight and appropriateness of compression garments. Regular treatment consisted of replacement of at least two compression sleeves at least twice a year. If LRV increased more than 5% or exceeded 20% since last check, intensive treatment with pneumatic compression, manual lymph drainage and bandaging were performed [5,6] for approximately one week. The patients were advised to wear the compression sleeve during the daytime but some patients with more severe lymphoedema also used an old sleeve (providing lower compression) during night. Some patients with very mild lymphoedema modified their daily compression sleeve routine to occasional use, wearing it only for activities they felt could worsen their lymphoedema.

Fifty-six patients attended the follow-up visits regularly twice a year and 42 did not come regularly but were measured and treated at all visits that they attended.

Data from time of diagnosis and 1, 2, 4, 6, 8 and 10 years after the time of diagnosis of BCRL was collected from the patients’ record.

Controls. The controls were measured at least twice within one year of the end of primary medical treatment and were found to have no BCRL. No further follow-up had been made until measurements were performed at time of the study. Data from time of diagnosis (Table I) was collected from the patients’ record.

Statistics. Assumptions of normality and homogeneity were checked graphically for the different defined groups. Since no deviations from these assumptions were found, the two-sample t-test was used to compare mean values between the defined groups.

Paired t-test was used to compare groups in Table V.

A level of significance was set at 0.05.

Results

The lymphoedema group had a significantly (p ≤ 0.001) larger LRV than the control group (Table I).

The mean LRV was 8.1 ± 3.6% at time of diagnosis of arm lymphoedema (n=98). At time of last follow-up measurement (mean 48.9 ± 39.2 months from diagnosis) the mean LRV was 9.0 ± 6.7% with no significant change compared to LRV at time of diagnosis. At BCRL diagnosis the mean BMI was 25.8 ± 4.1 and at last follow-up 25.7 ± 4.2 with no significant difference. The distribution of the patients in regard to LRV at time of the last measurement is presented in Figure 3. Fifteen patients had last follow-up less than six months after BCRL diagnosis. Of the remaining 83 patients, 22 (26.5%) were below LRV 5% at last follow-up measurement (mean 58.1 ± 38.2 months from diagnosis) and 11 patients (13.3%) exceeded LRV 20% (59.6 ± 25.4 months).

The number of patients included in each year category along with the average LRV at time of diagnosis and last measurement are presented in Table III. No difference in LRV was found between first and last measurement in any year category.

The total number of patients recorded at each follow-up milestone, along with the average LAV...
and LRV are presented in Table IV. The data show a reduction of LRV the first year after BCRL diagnosis. It also shows that the highest LRV (13.4 ± 12.8%) were found four years after BCRL diagnosis with a significant increase compared both to measurements at start (Table IV) and at two years (Table V).

**Early or late diagnosis**

Mean LRV for patients diagnosed with BCRL at an early stage (n=70) was 8.4 ± 3.9% at time of diagnosis and 9.5 ± 6.7% at last follow-up measurement (mean 52.6 ± 40.4 months). Corresponding results for late stage (n=28, 29%) was 7.5 ± 2.6% and 7.7 ± 6.8% (mean follow-up time 39.8 ± 35.0 months). There were no differences within or between the groups.

Nine patients (12.9%) in the early stage group and two patients (7.1%) in the late stage group exceeded 20% LRV at last follow-up measurement.

**Small or large lymphoedema relative volume at diagnosis**

Mean LRV for patients with small arm lymphoedema (n=79, 81%) was 6.8 ± 1.6% at time of diagnosis and increased (p=0.01) to 8.6 ± 6.7% at last follow-up measurement (mean 47.8 ± 39.0 months). Corresponding results for large arm lymphoedema (n=19, 19%) was 13.5 ± 4.5% with a reduction (p=0.02) to 10.6 ± 6.7% at last follow-up measurement (mean 53.8 ± 40.1 months). There was a significant difference between the groups at time of diagnosis (p ≤ 0.001) but not at time of last follow-up.

Eight patients (10.1%) in the small arm lymphoedema group and three patients (15.8%) in the large arm lymphoedema group exceeded 20% LRV at last follow-up measurement.

**Regular or non-regular treatment**

Mean LRV in the regular treatment group (n=56, 57%) was 8.9 ± 4.3% at time of diagnosis and 9.1 ± 7.1% at last follow-up measurement (mean 38.9 ± 31.3 months). Corresponding results for the non-regular treatment group (n=42, 43%) was 7.1 ± 2.1% at time of diagnosis and 8.7 ± 6.2% at last follow-up measurement (62.3 ± 44.7 months). The regular treatment group had larger (p = 0.01) LRV at time of diagnosis and thereby also at start of

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Table IV. Lymphoedema absolute (ml) and relative volume (%) at 1, 2, 4, 6, 8 and 10 years after diagnosis of breast cancer related arm lymphoedema.

<table>
<thead>
<tr>
<th>Follow-up years</th>
<th>Number of patients</th>
<th>mean LAV ± SD, ml</th>
<th>mean LRV ± SD, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>start</td>
<td>98</td>
<td>183.5 ± 79.1</td>
<td>8.1 ± 3.6</td>
</tr>
<tr>
<td>1</td>
<td>70</td>
<td>167.7 ± 123.1</td>
<td>7.3 ± 5.2*</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>197.9 ± 171.1</td>
<td>8.6 ± 7.0</td>
</tr>
<tr>
<td>4</td>
<td>38</td>
<td>308.6 ± 313.9</td>
<td>13.4 ± 12.8*</td>
</tr>
<tr>
<td>6</td>
<td>28</td>
<td>276.4 ± 231.3</td>
<td>11.4 ± 9.1</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>271.6 ± 228.4</td>
<td>11.4 ± 8.0</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>153.7 ± 57.9</td>
<td>7.4 ± 3.1</td>
</tr>
</tbody>
</table>

LAV; lymphoedema absolute volume
LRV; lymphoedema relative volume
*p=0.05, compared to LRV at start

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Table V. Comparison of lymphoedema relative volume (LRV) by years after diagnosis of breast cancer related arm lymphoedema (LE).

<table>
<thead>
<tr>
<th>Categories by years since LE diagnosis in participants with completed volume measures1</th>
<th>1 year mean ± SD LRV% (n)</th>
<th>2 years mean ± SD LRV % (n)</th>
<th>4 years mean ± SD LRV % (n)</th>
<th>6 years mean ± SD LRV % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time points of measurement comparison:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start/1y</td>
<td>8.6 ± 4.0/7.3 ± 5.2* (70)</td>
<td>9.1 ± 4.4/8.0 ± 5.7 (49)</td>
<td>8.9 ± 4.2/7.7 ± 5.6 (34)</td>
<td>9.0 ± 4.6/7.0 ± 6.1 (23)</td>
</tr>
<tr>
<td>1y/2y</td>
<td>- -</td>
<td>8.0 ± 5.7/8.6 ± 7.1 (49)</td>
<td>7.7 ± 5.8/8.9 ± 7.1 (32)</td>
<td>7.8 ± 7.2/7.7 ± 6.4 (15)</td>
</tr>
<tr>
<td>2y/4y</td>
<td>- -</td>
<td>- -</td>
<td>8.9 ± 7.0/12.1 ± 10.1** (33)</td>
<td>7.6 ± 6.2/14.4 ± 12.6** (16)</td>
</tr>
<tr>
<td>4y/6y</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>17.4 ± 16.2/12.6 ± 8.8 (19)</td>
</tr>
</tbody>
</table>

1 No analysis was carried out for the category 8 years (n=7) and 10 years (n=2) as numbers were few.
*p=0.05, **p=0.01
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spectroscopy in breast cancer patients treated with axillary dissection and radiotherapy [17–19]. This shows that the present study group had the same risk for development of lymphoedema as similar cohorts.

In the present study BCRL was identified and treated at an early stage. When BCRL is not treated one can expect a much larger LRV than found in the present study, some years after diagnosis, according to Casley-Smith [7]. He verified that untreated arm lymphoedema increases in amount with time and found LRV to be 22% (n=67) about two years after diagnosis and 77% (n=16) after about eight years. His results can be compared to the results of the present study with 8.6% and 11.4% respectively when BCRL has been diagnosed early and properly treated. Similarly, Ramos et al. [20] showed a mean LRV of 23% in patients with BCRL who had not been treated in mean 3.6 years (n=69), compared to 13.4% in four years (n=38) in the present study. These notable differences in LRV between the cohorts can be explained by the fact that the lymphoedema treatment was started at a very early stage in terms of volume (mean 8.1% in the present study). However, it could be argued that BCRL, even when it is identified late, can be reduced to about half the amount by Complex Decongestive Therapy. Applying this to the Casley-Smith study about 35% LRV still remains, which is three times the LRV found in this study.

Stillwell also defined “slight” lymphoedema as LRV being 11–20% and LRV below 10% he called “insignificant” [21]. Probably due to this classification, 10% has been regarded as the lower limit of diagnosis of BCRL [2,17,22]. However, the definition of BCRL as LRV 5% instead of 10% is important for early diagnosis and treatment. It is easily explained by the fact that the normal difference between dominant and non-dominant arm is 1.4–1.6% [21] and the BCRL obviously starts developing within the range approaching LRV 10%. This trend towards a lower cut-off point for definition has also recently been used in other studies. Stanton et al. [13] defined BCRL as LRV 5%, and others used 3% (though in comparison to the preoperative volume of the affected side and not the contralateral side) [12].

As there are individual changes in the normal difference between the arms the 5% definition must be supplemented with palpation of increased skin and subcutaneous tissue to make a diagnosis of BCRL. In this retrospective study we explored the development of arm volume in patients with breast cancer related lymphoedema. Results reveal that BCRL can be identified at an early stage both in regard to time of diagnosis after operation and to edema volume, and that edema volume can be kept at a low level for at least 10 years.

In this study we included only patients with both axillary dissection and radiotherapy, as they were more likely to increase LRV compared to a non-axillary radiotherapy group [2]. The results revealed that the lymphoedema incidence (38.7%) was quite “normal” and similar to several other studies (33–54%) measuring arm volume with volumetry or bioimpedance spectroscopy. In the present study BCRL was identified and treated at an early stage. When BCRL is not treated one can expect a much larger LRV than found in the present study, some years after diagnosis, according to Casley-Smith [7]. He verified that untreated arm lymphoedema increases in amount with time and found LRV to be 22% (n=67) about two years after diagnosis and 77% (n=16) after about eight years. His results can be compared to the results of the present study with 8.6% and 11.4% respectively when BCRL has been diagnosed early and properly treated. Similarly, Ramos et al. [20] showed a mean LRV of 23% in patients with BCRL who had not been treated in mean 3.6 years (n=69), compared to 13.4% in four years (n=38) in the present study. These notable differences in LRV between the cohorts can be explained by the fact that the lymphoedema treatment was started at a very early stage in terms of volume (mean 8.1% in the present study). However, it could be argued that BCRL, even when it is identified late, can be reduced to about half the amount by Complex Decongestive Therapy. Applying this to the Casley-Smith study about 35% LRV still remains, which is three times the LRV found in this study.

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fullness of the medial elbow and distal upper arm contours, and pitting edema. In practice, these signs of lymphoedema are well-known but they have not been tested for validity or reliability. However, it is also our experience that these signs, increased thickness of the subcutaneous tissue in particular, can contribute to confirmation of the clinical diagnosis. Therefore, we included this method together with arm volume measurements to diagnose BCRL.

A reduction of BCRL was found the first year after diagnosis (Table IV and V) showing that the initial treatment with compression sleeve was effective. After initial treatment 17 patients chose to have no further treatment. Eleven of these patients (11% of the BCRL group) were followed for more than six months revealing that eight had no increase but three exceeded 10% LRV. These findings suggest that the initial increase of volume stopped either spontaneously or due to initial treatment with compression sleeve. The last alternative is supported by Stout Gergich et al. [12] who found that compression garments could effectively treat BCRL and maintain volume reduction at an average follow-up of five months. However, there might be a need to determine whether some BCRL stop volume increase spontaneously on a low level.

It is argued that 10% is an adequate cut-off point to stratify into small LRV and large LRV groups. We found an increase to more than 20% LRV in 16% of the patients with large LRV at diagnosis, but only 10% of the patients with small LRV. On the other hand 13% of the patients with early diagnosis but only 7% of those with late diagnosis, increased to more than 20% LRV. These findings suggest that it may be more important to use LRV as a predictor for positive outcomes rather than timing. This is supported by Ramos et al. [20] who stated that the initial volume of oedema is the key to successful treatment regardless of whether the intervention is early or late.

After the first year of reduction of LRV, it was observed to increase again with significant differences compared to both the LRV at start and at two years. An explanation for this increase between two and four years after BCRL diagnosis cannot be found in the present data. One hypothesis might be that BCRL has been found not to develop at once in the entire arm [24], thus delaying the total volume increase until the entire arm is involved. The two to four year increase may also be due to psychosocial aspects, including lack of compliance to treatment. Patients are probably more motivated to use a compression sleeve close after the diagnosis of BCRL. When patients experience that the size of their arm does not increase rapidly or at all, compliance to continuously wear a compression sleeve may be jeopardized.

This study demonstrates that early diagnosis and treatment of unilateral arm lymphoedema can maintain relative arm volume at low levels for a period of up to 10 years after diagnosis of BCRL. The incidence of BCRL has been shown to be 38.7% during the follow-up period. The results have shown that a higher percentage (not significant) of patients with a large LRV at diagnosis, as compared to patients with a small LRV at diagnosis, progressed to an LRV of greater than 20% during the follow-up period. No significant difference was found between the LRV for late stage and early stage at time of diagnosis or last follow-up. This demonstrates the importance of early diagnosis with respect to arm volume (as opposed to time since medical treatment) in halting the progression of lymphoedema before the relative volume of the arm increases too much.

In conclusion, the present study shows that BCRL can be identified at an early stage both in regard to time of diagnosis after operation and to edema volume, and that edema volume can be kept at a low level for a long time. The future challenge in this area will be to improve objective measurements and to validate subjective ones for early identification of BCRL.

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References