Water Contamination and the Rate of Infections for Water Births

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Abstract: *Objective:* The potential for increased risks of infection is an important concern with water births. We performed microbiological analyses on water samples taken from birthing pools before and after water births, and compared the rate of neonatal infection arising after water births with that arising after conventional delivery.

Materials and Methods: In this prospective observational study beginning in 2001, water from the delivery pool was analyzed to determine the prevailing microorganisms. Two water samples were taken at each delivery. The first sample (sample A) was taken after the tub was filled with tap water; the second sample (sample B) was taken after the delivery. The high rate of water contamination with *Legionella pneumophila* and *Pseudomonas aeruginosa* led us to install a filter system (Aquasafe –Filter[R]) into the supply hose for the birthing pool to reduce the water contamination. This intervention significantly reduced the total microbial loading and there was no longer evidence of *Legionella pneumophila.* Furthermore, we determined the rate of neonatal infections in infants delivered in water and compared it with those delivered conventionally out of the water.

Results: Samples were obtained from 300 out of a total of 1,625 water deliveries, which took place between 2001 and 2007. Before the installation of a filter system, 29% of the A-samples showed bacterial growth with *Legionella pneumophila*, 22% with *Pseudomonas aeruginosa*, 18% with enterococci, 32% with coliforms, and 8% with *Escherichia coli*.

After the installation of the filter system, the water contamination decreased considerably:

- there were no further signs of Legionella bacteria, and Pseudomonas aeruginosa was found in only 3% and coliforms in 13% of the samples, respectively.

By comparing the microbiological composition of the B-samples before and after installation of the filter system, we concluded that the intervention did not influence the microbial loading of the water, which occurred during and as a result of the whole delivery phase. The microbiological loading of the water in the birthing pool after it was filled may have partly originated from the insufficient cleaning and disinfections of the birthing pool and after changing the cleaning records there was no longer any evidence of a significant microbial count (unpublished data).

Of the B-samples, 82% contained large amounts of coliforms, 64% contained *Escherichia coli* with concentrations of up to 105 CFU/100 mL, and 8-12% contained *Pseudomonas aeruginosa. Staphylococcus aureus* and Candida spp were also present in moderate amounts.

The rate of neonates treated with antibiotics for suspected infection on the basis of clinical symptoms (tachypnoea, skin color) or laboratory findings (CRP rise, leukocytosis) was 1.05% after water births (17 out of 1,625) compared with 1.75% (20 out of 1,139) after conventional delivery ($p < 0.05$).

Conclusion: Based on our results and the literature, water birth is a valuable alternative to traditional delivery when certain criteria are met and risk factors are excluded. During water birth, faeces are discharged into the pool and the water is contaminated with a variety of microorganisms. However, contamination of the water with such microorganisms seems not to translate into an increased risk of neonatal infection.

Keywords: Water birth, microbiological colonization, delivery, infections, fetal outcome.

INTRODUCTION

In Europe an increasing number of women want to give birth in the water. In our institution we perform water deliveries since 1996, about 40 – 50 % of approximately 530 women per year give birth in the water.

Since the first reports on water birth were published more than 20 years ago [1-3], there have been ongoing debates about the safety, potential risks and general outcome.

Main advantages of water birth have been reported to be a decrease in episiotomies, pain medication and epidural anaesthesia [4]. Also, maternal blood loss was observed to be lower after delivery in the water whereas fetal outcome and maternal infection rate did not differ between the study groups [3].

One main concern remains for hygienists [5], obstetricians [6, 7] and neonatologist: the microbiological contamination of the mother and the newborn after water delivery due the faecal and skin flora of the mother and environmental bacteria from the water system. Because the water is

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Table 1. **Parameters Examined and their Significance**

Parameter	Methods	Examination	Notes
Coliforms	Stand. Meth. 20th ed. 9222B	After filling the pool and after delivery (Sample A and B)	Standard hygiene indicators in the examination of drinking water or bathing water; increased values also indicate insufficient cleaning and disinfection of the pool
Escherichia coli	MU 1185:2001		
Enterococci	ISO 7899-2:2000		
Pseudomonas aeruginosa	Internal methods		Can accumulate in furred pipes and reservoirs
Total microbial count	ISO 6222:2000	After filling pool (Sample A)	General microbiological loading
Legionella pneumophila	ISO 11731: 1998		Can multiply in hot water pipes and water reservoirs
Staphylococcus aureus, Candida spp.	Internal methods	After delivery (Sample B)	Originate mainly from skin and mucous membranes

at body temperature, bacteria can multiply quickly and infect both the newborn and the mother after water birth [8, 9].

Therefore the aim of this study was to analyze the microbial contamination of the bath water, by analyzing 2 samples, one after filling the pool, and the other after the delivery of the newborn. Additionally we compare fetal outcome data and neonatal infection rates after deliveries in the water with those born conventionally.

MATERIALS AND METHODS

During the period from 2001 to 2007, a total of 1,625 water births were recorded at the Women`s Hospital of Vipiteno, Italy, in addition to 1,139 vaginal deliveries, excluding the deliveries done by caesarean section.

A prospective study was done in cooperation with the Biological Laboratory of the Environmental Agency of the Province of Bolzano and from 2001 onwards, the water in the birthing pool was sampled for microorganisms. The microbiological composition of the water was determined in 300 of the total 1,625 water births. Of the 300 water births analyzed, 125 occurred before the installation of the Aquasafe Filter[R] (PALL) system into the supply hose for the birthing pool and 175 occurred thereafter.

Two water samples were taken for microbial analysis at each delivery. For sample A, the water was taken using a sterile bottle immediately after the pool was filled with water. Sample B was taken after the mother had left the birthing pool following the delivery. Both samples were transported to the laboratory, where the tests took place within 24 hours of collection. Six parameters were analyzed for the A-samples and five parameters were analyzed for the B-samples (Table **1**). The A-samples were analyzed for the standard hygiene indicators such as coliforms, *Escherichia coli*, Enterococci, *Pseudomonas aeruginosa* and *Legionella pneumophila,* which can form biofilms on warm water pipe surfaces [9]. The total microbial count indicates the general bio-burden.

Laboratory Standard Values

The water was not considered contaminated if the number of hygiene indicators in 100 mL was 0 (following the general water requirements for human use), there was no evidence of Legionella in 1 mL, and the total microbial count was <500 CFU/1 mL (Table **2**) [10, 11].

In the water samples collected after delivery (B-samples), five parameters were examined. They were mainly influenced by the contamination of the pool with maternal faeces.

Table 2. **Laboratory Criteria of Valuation**

Parametes	Criteria	unit	Valuation
Coliforms, *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus*, Enterococci, Yeasts	0	KBE/100ml	not contaminated
	<= 100	KBE/100ml	slightly contaminated
	> 100	KBE/100ml	contaminated
Total microbial loading	< 500	KBE/1ml	not contaminated
	>= 500 bis < 1.000	KBE1ml	slightly contaminated
	> 1.000	KBE/1ml	contaminated
Legionella pneumophila	not detectable	P/A in 1 ml	not contaminated
	detectable	P/A in 1 ml	contaminated

Table 3. Clinical Findings for Neonates

Method of delivery	Conventional birth n = 1.139	Water birth n = 1.625	P-value
Clinical signs of infection and respiratory distress (tachypnoea, flared nostrils, peripheral cyanosis)	20 (1.75%)	17 (1.05%)	P = 0.1
CRP (mg/dL) (normal value < 0.8)	2.82 ± 1.82	1.5 ± 0.2	P < 0.001
Umbilical artery blood pH	7.25 (7.03 – 7.46)	7.26 (7. 04 – 7.47)	P = 0.7
Base Excess (mmol/L)	-6.05 (-0.2 --- 13.8)	-5.35 (-0.6 --- 13.2)	P = 0.5

In addition to the coliforms, *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus,* and Candida spp. were cultivated.

All neonates underwent a daily physical examination. If there were clinical indications of an ensuing infection, a septic screen including CRP and white blood count testing was performed. Any local infection such as conjunctivitis and inflammation of the navel was documented [12, 13]. In addition, a leukocyte count was performed on day 1 or 2 after delivery for the 300 women who delivered in water and compared with the leukocyte count for another 300 women who had undergone conventional delivery.

Statistical analysis was performed with commercial software SPSS 11.5 (SPSS, Inc., Chicago, USA). Student`s *t* test and Welch test (if variances in groups are unequal) were used to compare approximate normally distributed data in the groups. Mann-Whitney *U* test or χ^2-test was used for the ordinal data. All variables used were described by median and standard deviation. A *P* value <0,05 was considered significant.

RESULTS

The results are listed in Figs. (**1** and **2**) and in Table **3**.

Since bacterial growth with Legionella (29%) and Pseudomonas (22%) was repeatedly found in the A-samples (Fig. **1a**), we decided to install the Aquasafe single use water filter system in the supply hoses for the birthing pool. This intervention significantly reduced the total microbial count from 53% to 11%, and there was no longer evidence of *Legionella pneumophila* (Fig. **1b**). The contamination with *Pseudomonas aeruginosa* was reduced from 22% to 3%. Contamination with coliforms was reduced from 32% to 13% by thoroughly cleaned the tub.

A further reduction of microbiological loading with Coliforms and Enterococci in the birthing pool after it was filled was reached by adoption of a new cleaning protocol for the birthing pool. (The pool was first cleaned with a detergent and then disinfected with a chlorhexidine product, unpublished data).

Faeces are discharged into the birthing pool water during the bearing down phase of childbirth. Thus, the water was contaminated with a large variety of microorganisms (Fig. **2**), including microorganisms from the mother's skin. Consequently, the B-samples taken from the pool after a water birth showed the presence of coliform loading before and after installation of the filter system in 92% and 88% of the samples, respectively. In 79% and 76% of the samples, there was evidence of contamination with Escherichia coli. Concentrations of up to 105 CFU/100 mL were measured for Escherichia coli and coliforms. On the other hand, loading was moderate with *Pseudomonas aeruginosa* (26% before installation of the filter system compared with 20% afterwards), *Staphylococcus aureus* (4% before installation of the filter system compared with 8% afterwards) and Candida spp (20% before installation of the filter system compared with 22% afterwards). By comparing the microbiological composition of the B-samples before and after installation of the filter system, we concluded that the intervention did not influence the microbial loading of the water, which occurred during and as a result of the whole delivery phase (Fig. **2**).

On average, the mothers` white blood count (WBC) did not show any significant difference between the two groups on the first or second day after delivery. The WBC for water births was 11.014/µL (6.200 – 16.900) compared to 11.210/µL (5.300 – 18.700) for conventional deliveries.

Although there was a high level of contamination with faecal bacteria in the water after birth, children born in water did not have an increased infection rate. Notably, there was no increase in the rate of focal skin infections around the umbilicus or eye infections such as conjunctivitis. There were fewer signs of infection in the children born in water; 1.13% of them showed symptoms of tachypnoea, flared nostrils, abnormal skin coloring, and increased CRP values compared with 2.03% of the children born conventionally (P < 0,05) (Table **2**). All neonates with these signs of infection were successfully treated with antibiotics.

DISCUSSION

A number of concerns were expressed about water births when they were first introduced. In the last few years, there have been a number of case reports of infections in children born in water [13-16]. Our prospective study concentrated on the hygienic aspects of water births. After birth, the water showed an increased amount of faecal indicators. There was evidence of total coliforms and *Escherichia coli* concentrations of up to 105 CFU/100mL. *Staphylococcus aureus*, *Pseudomonas aeruginosa, Candida* spp were also detected. However, this considerable loading did not cause an increase in the rate of neonatal infections in water births when compared with conventional births. There was also no increase in the number of maternal infections or poor healing of perineal tears in women who had given birth in water. These observa-
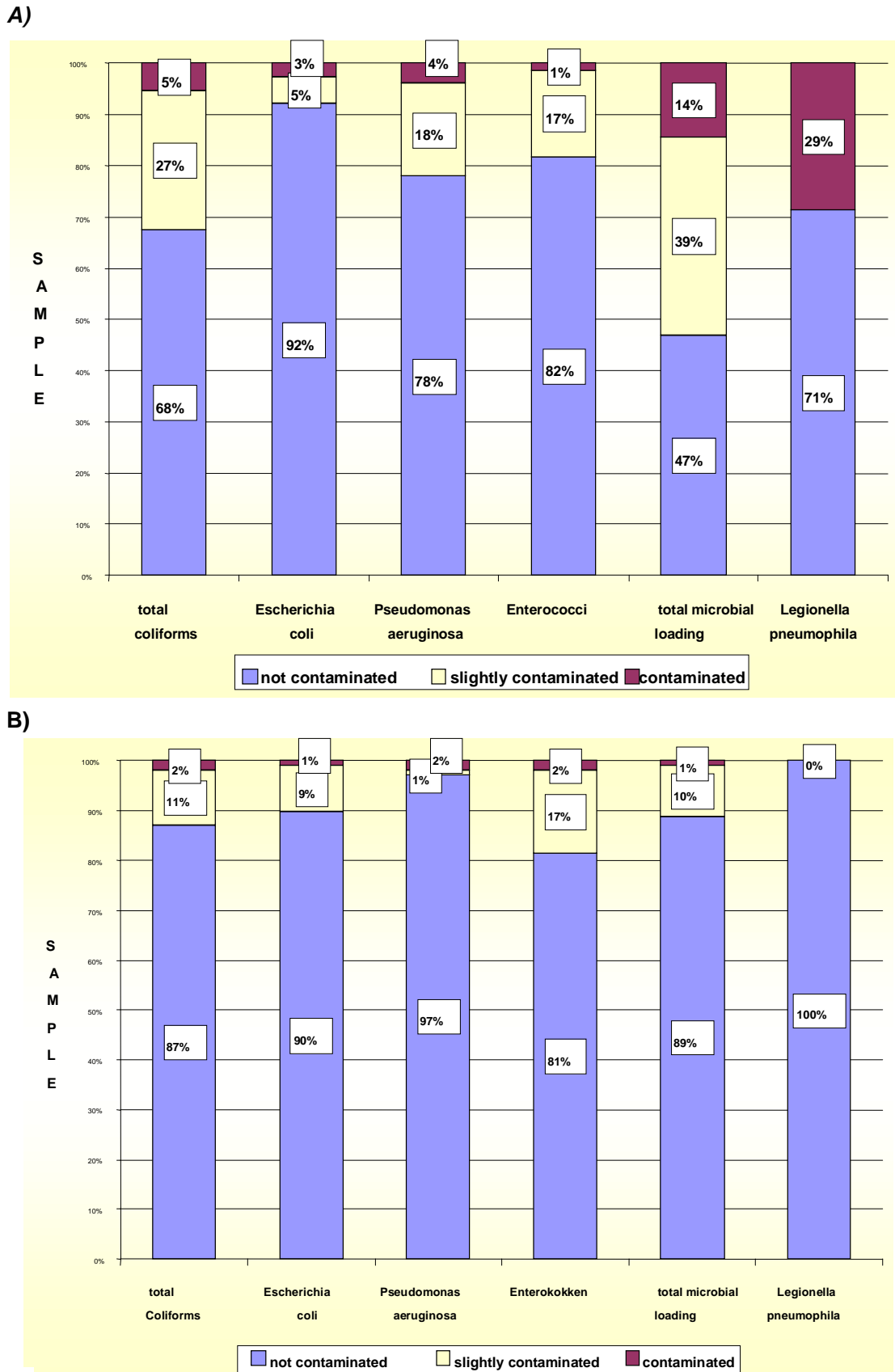
A)

B)

Fig. (1). Microbiological composition of the A-samples (birthing pool water after the tub was filled with tap water).

A) before installation of the filter system (n = 125).

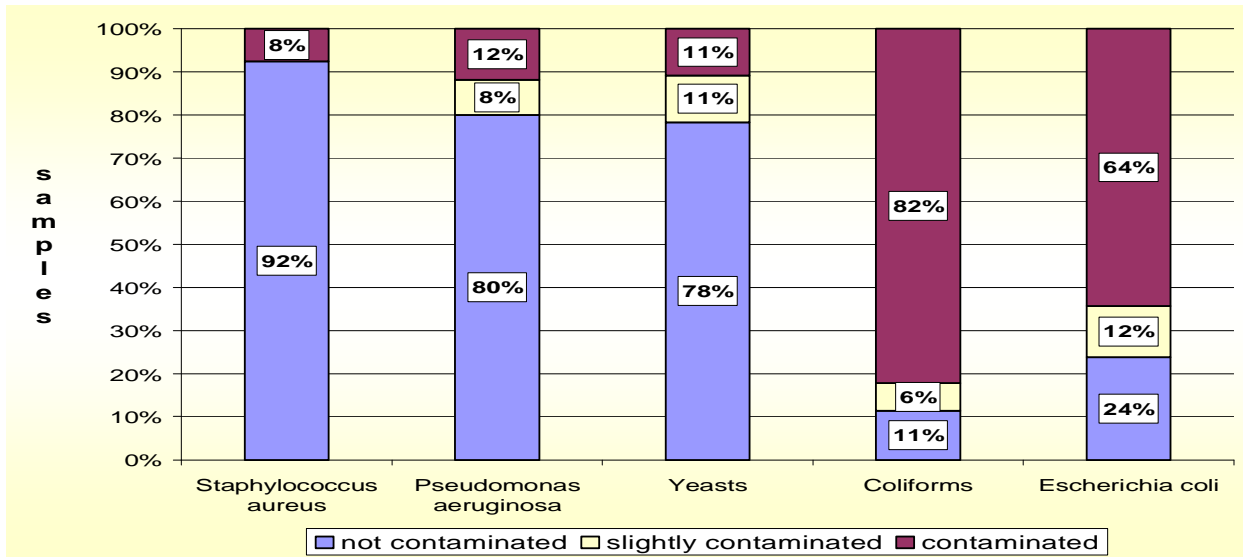**B**) after the installation of the filter system (n=175).

Fig. (2). Microbiological composition of the B-samples (water taken after delivery) (n = 300) after installation of the filter and adoption of different cleaning record.

tions further expand and confirm the studies by Gilbert *et al*. [17] and Kramer *et al*. [18], who did not find an increased rate of infection in children born in water. The water in the birthing pool was at body temperature and came from the public water supply, which is regularly checked by the health authorities. The contamination could have come from the peripheral pipe system of the hospital [11], but it may also have resulted from improper cleaning and disinfection of the pool [14]. After installation of the filter there was a significant reduction in the contamination of sample A from pool water with microorganisms, which predominantly originated from the plumbing system (Legionella, *Pseudomonas aeruginosa*, total microbial count). However, mothers and other sources of infection can also carry Pseudomonas aeruginosa. Thus, it is not possible to completely eliminate this germ. On the other hand, the reduction of the standard hygiene indicators such as total coliforms, *Escherichia coli* and enterococci was only minimal. Total coliforms, *Escherichia coli,* and enterococci are normally tested for in the drinking water on a regular basis by the local health authorities and who have not verified the presence of such organisms up to now. One can therefore assume that these microbiological indicators provide information on the hygienic conditions of the birthing pool.

Our study shows that the microbiological loading of the water in the birthing pool after it was filled may have partly originated from the insufficient quality of the drinking water, which was heated to body temperature, and partly from the insufficient cleaning and disinfection of the birthing pool. In the testing phase of the birthing pool after 2002, the cleaning protocol was changed (the pool was first cleaned with a detergent and then disinfected with a chlorhexidine product), and there was no longer any evidence of a significant microbial count (unpublished data). The water samples taken in the first few years after the installation of the birthing pool repeatedly showed increased levels of *Legionella pneumophila* (microbial count >103/L) and there was evidence of an increased concentration of these organisms in the shower hose, which occurred as a result of water stagnation. Drinking water does not have to be sterile to meet the require-

ments of the drinking and bathing water ordinance, and water can become contaminated in a hospital's plumbing system [11], thus, contamination of hospital drinking water with e.g. *Pseudomonas aeruginosa* or Legionella, as well as severe hospital-acquired infections, have repeatedly been described in babies born in water [19-21]. In 2001, the first year of the study period, attempts were made to eradicate Legionella by heating the water tank to over 60°C every day. However, these measures failed to clear the tap water. The contamination of heated drinking water was not reduced or controlled until the filter system was installed in 2002 [10]. The Aquasafe[R] single use water filters are delivered under sterile conditions and are changed before filling the birthing pool for each birth. The filters are installed at the end of the shower hose and the filter outlet is not allowed to dip into the pool water, i.e. care must be taken that it does not come into contact with the water in the birthing pool during the delivery, in order to rule out retrograde contamination of the filter outlet with microorganisms in the water. The filters must be changed in no later than seven days, even if they have not been used or if there have not been any water births. The filters undergo antibacterial treatment, although the new generation of water filters (Pall Medical disposable, single use water filters) offer the advantage that they do not have to be decontaminated. Comparing the results of the B-samples, which were taken after water birth, shows that there was no significant improvement in the microbiological composition of the water after the filter system was installed, as the loading occurred as a result of the delivery. There was, however no evidence of the complications expected as a result of water births, such as aspiration and increased infections for the neonate. This is probably due to the fact that the intrauterine diving or breath holding reflex remains fully effective during delivery and immediately afterwards in the water [22-24]. It is therefore physiologically impossible for the microorganisms excreted in the mother's faeces to enter the neonate's lungs and cause an infection.

In summary, both maternal faeces and the water supply are sources of contamination with potentially pathogenic microorganisms. However, water birth seems to not be asso-

ciated with an increased risk of neonatal or maternal infections in our series. Our data indicate that water deliveries are safe and not associated with adverse maternal or fetal outcome, when water supply system and bathing tube are serviced appropriately.

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REFERENCES

[1] Odent M. Birth under water. Lancet 1983; 2(8365-66): 1476-7.
[2] Daniels K. Water birth: the newest form of safe, gentle, joyous birth. J Nurse Midwifery 1989; 34(4): 198-205.
[3] Mackey M. Use of water in labor and birth. Clin Obstet Gynecol 2001; 44(4): 733-49.
[4] Geissbühler V, Eberhard J, Chifelle C, Stein S. A prospective comparison of 3000 water births and 4000 conventional deliveries. Geburtshilfe Frauenheilk 2001; 61: 872-79.
[5] Daschner F. Comment of a hygienist on water births. Geburtshilfe Frauenheilk 1999; 59: 632-33.
[6] Zimmermann R, Huch A, Huch R. Waterbirth-is it safe? J Perinat Med 1993; 21(1): 5-11.
[7] Rosevear SK, Fox R, Marlow N, Stirrat GM. Birthing pools and the fetus. Lancet 1993; 342(8878): 1048-9.
[8] Rawal J, Shah A, Stirk F, Mehtar S. Water birth and infection in babies. BMJ 1994; 309(6953): 511.
[9] Alderice F, Renfrew M, Marchant S, *et al.* Labour and birth in water in England and Wales. BMJ 1995; 310(6983): 837.
[10] Thoeni A, Oberhuber A, Moroder L. Giving birth and being born in the water. Experience after 1325 waterbirths. Int J Gynaecol Obstet 2003; 5(3-4): 113-20.
[11] Pietsch M, Schön K, Spielmann M, Werner HP. Existence and implications of Legionella in drinking water of Hospitals. Hyg Med 1988; 13: 265-7.
[12] Fehervary P, Lauinger-Lörsch E, Hof H, Melchert F, Bauer L, Zieger W. Water birth: microbiological colonisation of the newborn, neonatal and maternal infection in comparison to conventional bed deliveries. Arch Gynecol Obstet 2004; 270(1): 6-9.
[13] Parker PC, Boles RG. Pseudomonas otitis media and bacteremia following a water birth. Pediatrics 1997; 99(4): 653.
[14] Vochem M, Vogt M, Döring G. Sepsis in a newborn due to *Pseudomonas aeruginosa* from a contaminated tub bath. N Engl J Med 2001; 345(5): 378-9.
[15] Ridgway GL, Tedder RS. Birthing pools and infection control. Lancet 1996; 347(9007): 1051-2.
[16] Hawkins S. Water vs. conventional births: infection rates compared. Nurs Times 1995; 91(11): 38-40.
[17] Gilbert RE, Tookey PA. Perinatal mortality and morbidity among babies delivered in water: surveillance study and postal survey. BMJ 1999; 319(7208): 483-7.
[18] Kramer A, Hoyme UB, Schrader G. Underwater births. Hyg Med 2000; 25: 94-6.
[19] Coombs R, Spiby H, Stewart P, Norman P. Water births and infection in babies. BMJ 1994; 309(6961): 1089.
[20] Franzin L, Scolfaro C, Cabodi D, Valera M, Tovo PA. *Legionella pneumophila* Pneumonia in a newborn after water birth: a new mode of transmission. Clin Infect Dis 2001; 33(9): e103-4.
[21] Nagai T, Sobajima H, Iwasa M, *et al.* Neonatal sudden death due to legionella pneumonia associated with water birth in a domestic spa bath. J Clin Microbiol 2003; 41(5): 2227-9.
[22] Tschobroutsky C. The diving reflex in rabbit, sheep and newborn lamb and its afferent pathways. Respir Physiol 1969; 8(1): 108-17.
[23] Johnson P. Birth under water - to breathe or not to breathe. Br J Obstet Gynaecol 1996; 103(3): 202-8.
[24] Dawes GS. Breathing before birth in animals and men. An essay in developmental medicine. N Engl J Med 1974; 290(10): 557-9.