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Microbes Free Air Supply in MUHC During Construction

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Abstract

Hospital is an important environment characterized by spreading of airborne pathogens. Its indoor air quality (IAQ) is probably the most commonly discussed aspect of building indoor environmental conditions of modern societies since it has direct effect on the health of patients and hospital personnel [1,2]. Increasing number of scientific publications show that the heating, ventilation and air conditioning (HVAC) system may be implicated in disease transmission, and that air supply ducts can be contaminated by a variety of pathogens during renovation and/or construction of hospital buildings [3]. This situation generates significant concerns for the modern societies. According to the Center for Disease Control and Prevention, about 88000 patients die each year from nosocomial (hospital acquired) infections. From that number, it is estimated that about 2000 to 3000 deaths are associated with infections caused by airborne microbes [4,5]. However, standards for construction of healthy hospitals seem to be inexistent. Recently, Montreal based company, Ventilabec Inc. has made an important step forward by developing a new method for production, installation and protection of air ducts in HVAC system of a new building of MUHC. The new method consists in manufacturing of air ducts from galvanized metal sheet in which internal surfaces were cleaned, disinfected and end openings sealed with plastic wrap prior to installation in new HVAC system of the hospital building. Microbial and dust contamination protection of air ducts has been evaluated by visual inspection and microbial analysis of in-duct air and internal surface dust on 14 experimental ducts produced, installed and protected by the new method, as well as 6 control ducts, manufactured by standard procedure, non disinfected and non sealed with plastic wrap. Visual control of interior of ducts and sampling of in-duct air and dust from internal surfaces of ducts have been performed 6 times over 5 months studying period and analysed for total count of aerobic and anaerobic bacteria (TAAC), and total mould and yeasts (TMY) [6,7]. Visual inspection of control ducts has shown progressive accumulation of dust and construction material debris on internal surface of control ducts. The same evaluation of experimental ducts resulted in observation of its perfectly clean internal surface, with the exception of three ducts where construction dust was observed on the internal surface of access doors by the last sampling sessions. Analyzed microbial flora of control ducts has shown constant progression in total number of aerobic and anaerobic bacteria moulds and yeast. Microbial load of experimental ducts was characterized by low number of bacteria, molds and yeasts, which remained rather constant and without significant variations. Present study suggests that the new method of installation and protection of air supply ducts during building construction secures safety of HVAC system of the hospital building in construction.

Keywords: *Soil acidification; Nitrogen fertilizer; Aluminium*

Abbreviations: MUHC: McGill University Health Center; IAQ: Indoor Air Quality; HVAC: Heating Ventilation Air Conditioning; TAAC: Total Aerobic and Anaerobic Bacteria Count; TMY: Total Count of Molds and Yeasts

Introduction

Montreal is experiencing major change as simultaneous construction of two super hospital centers are on the way, which constitute the biggest building projects since the 1976 Olympic Games. One of the super hospitals is the multibillion dollar McGill University Health Center (MUHC), located on Glen Campus, which represents giant leap forward into modern era of "personalized medicine".

The Glen Campus of the MUHC combines the Royal Victoria Hospital, The Montreal Children's Hospital, Montreal General Hospital, The Montreal Chest Institute, Montreal Neurological Hospital, The Cancer Center and The Research Institute of MUHC at a single ultra-modern site. The Lachine Hospital and Camille-Lefebvre Pavilion joined, adding community focused hospital to the MUHC. The campus will also house the Shriners Hospital for Children. This ambitious merge was to create a modern era academic health care mega center where the competences of the founding hospitals and institutes will be consolidated for the benefit of patients, staff, education and scientific research.

Recent reports have defined causal links between construction or renovation and infection rates in health care institutions [1,3,8]. Thus, the actual practices and procedures during construction of MUHC were targeted as a major risk of introducing pathogens/or providing suitable habitants for their ulterior propagation throughout the air supply ducts inside of the Health Center.

As part of implemented strategy, Montreal base company Ventilabec Inc. has specifically developed a new method consisting of manufacturing and installation of microbe free air supply ducts and protecting their inside against microbes over construction period of time [9].

This new method may have important impact in establishing standards for healthy indoor environment of hospitals in construction aiming to prevent or reduce nasocomial infections which are becoming an uprising challenge throughout the world. The MUHC is in final stage of works, and will employ over 8000 professionals next year for providing services to thousands of patients and visitors on daily basis.

New Microbe Free Method of Manufacturing, Installation and Protection of Air Supply Ducts During Hospital Building Construction

All ducts used in the present study were produced according to HVAC Duct Construction Standards, as specified by Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) [10].

Following manufacturing, all internal surfaces of ducts have been manually cleaned and disinfected, using Spectro-Sept 312 cleaning and disinfecting agent (Laboratories Choisy Ltée, Louiseville, Québec, Canada) (Figure 1).

Then, the interior of ducts have been visually inspected, to ensure they are free of debris, and end openings have been sealed with polyethylene plastic wrap (Figure 2).

Before the installation of individual duct section they were visually inspected once again to ensure they are clean and then fitted in position upon completion of each section of the HVAC system. Each free opening was sealed again with the plastic wrap and so protected during period of construction and of the present study. Use of plastic wrap to seal ductwork is not new. However, effect of complete treatment, including production, cleaning, disinfection and sealing of duct openings on dust accumulation and microbial growth inside installed ducts in the building during construction has not been documented yet.

Figure 1: *Cleaning and disinfection procedure of air ducts.*

a. Cleaning and disinfection of air ducts.

b. Efficacy of cleaning and disinfection of air ducts.

Figure 2: *Sealing of openings of duct by plastic foil.*

Study Protocol

The assessment of the IAQ risks to the hospital buildings occupants has become a complex and challenging issue for the involved conceivers and analysts.

Many methods have been used to evaluate the cleanliness of the HVAC systems. The most commonly used methods for evaluation of the air duct are based on visual inspection and microbiological testings [6].

Two groups of air ducts have been included in the present study.

a. Group I of 6 ducts, which served as control, were produced using standard manufacturing procedures. These ducts have not been treated by cleaning and disinfection with microbicidal agent and the end openings have not been protected by plastic wrap prior to the transportation to the MUHC nor during period of its construction. Interior of these ducts have been physically exposed to the building indoor air during construction over the period of the present study [11].
b. Group II included 14 experimental ducts, which were manufactured, cleaned, disinfected, installed and end openings sealed with plastic wrap, according to the new method previously described.

Following visual inspection of interior of each duct from both groups, the following samples have been taken, according to standard protocols [7,12] for microbiological testings:

a. Air from inside of ducts, and
b. Dust from internal surfaces of ducts.

The above samples have been taken 6 times during 5 months of construction period in 2013, on following dates: May 21st, July 08th, August 20th, September 9th, September 30th and October 7th. Each sample of both groups of ducts has been used in present study for the following microbiological analysis, according to the standard protocols [7]:

a. Total count of aerobic and anaerobic bacteria (TAAC), and
b. Total count of molds and yeasts (TMY) [13].

Results

Visual inspection of internal surface of Group I ducts allowed to observe increasing accumulation of dust and construction materials debris over period of present study. Contrarily, the internal surface of Group II ducts remaining perfectly clean over construction and studying period of 5 months.

However, by the 4th and the 5th sampling session, minor but observable amount of drywall dust has been noticed on the internal surface of one and two duct service doors, respectively, as shown in Figure 3.

Figure 3: *Dust on internal surface of air duct access door.*

TAAC and TMY count of in-duct air and of the dust from internal surfaces of Group I ducts have shown steady and significant microbial growth progression during study period, as shown in Figure 4 and Figure 5.

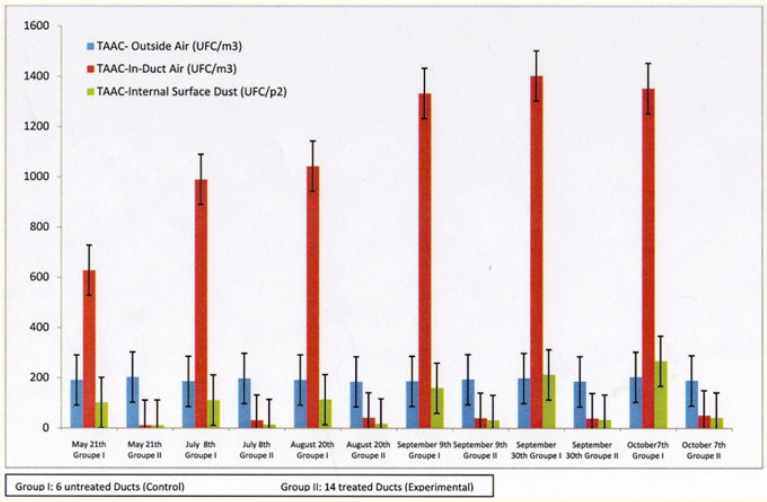

Figure 4: *Total aerobic and anaerobic bacteria count (TAAC) of outside air, in-duct air and internal surfaces.*

The TAAC and TMY analysis of in-duct air and of dust of internal duct surfaces of experimental Group II ducts have shown a low microbial incidence in both categories of samples during 5 months of study and construction period. Minor and non significant microbial count variation has been noticed without specific tendency, as shown in Figure 5.

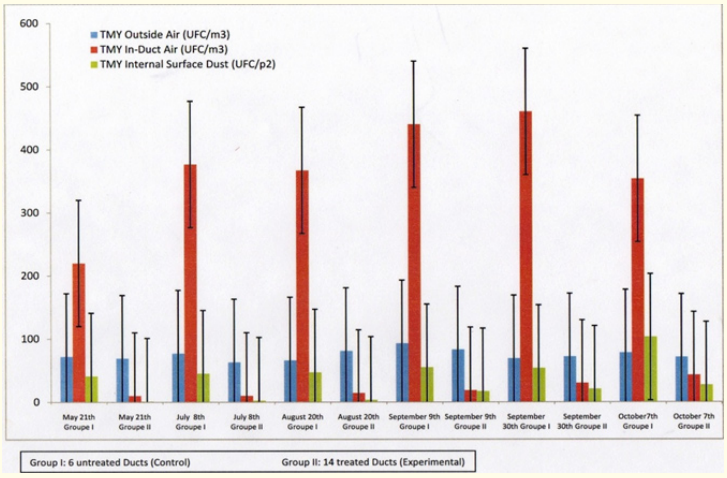

Figure 5: *Total count of mould and yeasts (TMY) of outside air, in duct-air and internal surface dust.*

Discussion

Indoor air quality is essential in order to assure the health of a hospital building. Thus, IAQ is probably the most challenging aspect among indoor environmental conditions of hospital settings because of its direct effect on the health of both patients and employees [1,2].

Recent studies reviled that HVAC systems may also get contaminated during construction of hospital building, especially if duct endings are not protected against moisture, dust and microbial entrance. Under these conditions ductwork may become so contaminated generating nosocomial infections. However, there is a visible absence of standard practice and advice for general contractors that provide both practical and standard care for managing IAQ risks in healthcare building construction [14].

The production and installation of healthy ducts and protecting them against dust and microbial contamination during construction is a vital requirement for assuring IAQ of the new building. This procedure involves steps to follow in order to achieve healthy indoor air environment of a new building.

Producing air ducts without residual oil are the best ways to prevent dust accumulation and microbial proliferation on the internal duct surface during the construction process [3]. Oil processing lubricants are used to decrease friction during the manufacturing process, especially of round air ducts and other components. Sticky oil residuals on internal the duct surface provide a good adhesive for dust particles which facilitate microbial adherence and subsequent growth. This initial contamination of air ducts, if not eliminated before beginning of HVAC functions, may affect IAQ of the new building and entail complex hospital situation and expensive cleaning procedures [6].

The sealing of openings of ductwork and diffuser during building construction with plastic foil assures significant reduction of entrance of the quantity of microbes, dust and moisture in HVAC systems which can lead to very costly IAQ problems later on.

However, this procedure does not eliminate all possibility of contamination of interior of installed and sealed ductwork. The high differential indoor air pressure may cause penetration of construction contaminated indoor air in installed docks if not adequately sealed during installation. Also, plastic foil used for sealing ductwork openings may be accidently ruptured. Above situations can also be facilitated by the in-duct lower differential pressure [9].

Thus, internal conditions of sealed duct work should be adequately controlled during construction process in order to identify all accidental contamination.

The simplest and less expensive way to evaluate in-duct cleanliness is the visual inspection, which allows the identification of numerous physic-sanitary conditions. When the dust concentration is lower than 0.1 g/m^2 dust is not visually identifiable and duct is considered as clean. However, no qualitative, health based exposure guidelines or thresholds can be recommended for acceptable levels of contamination by microorganisms [15].

Conclusion

Results of the present study justifies following conclusions:

a. Involvement of a multidisciplinary team that includes experts in physico-chemical and microbiological evaluations of interior of HVAC systems seems to be mandatory during construction of a hospital building.
b. Manufacturing, installation and protection of HVAC systems of a building in construction should be performed according to the appropriate Environmental Plan of the Building.
c. Interior of air ducts, if exposed to the ambient air of the building in construction, may become rapidly contaminated by dust and microbes. This contamination increases over period of construction and may represent major IAQ problem later on.
d. Interior of air ducts produced installed and protected according to the present method will remain perfectly clean and almost without any microbial flora, as shown by the present study.
e. This new method should be considered by pertinent norms and regulation for the benefit of future construction of buildings.

Recent studies reviled that HVAC systems may also get contaminated during construction of hospital building, especially if duct endings are not protected against moisture, dust and microbial entrance. Under these conditions ductwork may become so contaminated generating nosocomial infections. However, there is a visible absence of standard practice and advice for general contractors that provide both practical and standard care for managing IAQ risks in healthcare building construction [14].

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