







Fig. 2: Percent humidity of four different intrapackage materials wrapped within green plain hospital cotton fabric at immediate to 60 minutes after removal from the sterilizing chamber. \*Statistically significant difference when compared with control group at  $p < 0.05$ . \*\*Statistically significant difference when compared with control group at  $p < 0.01$ . ##Statistically significant difference with  $p < 0.01$

inside the package and the packaging materials significantly affect intrapackage temperature and humidity, which should be considered carefully. Differences in temperature and humidity retaining properties, durability, and permeability of the materials are important factors that may cause contamination of the sterilized instruments.

Of these factors, the humidity is critical since the higher the humidity the greater chance for contamination. The range of acceptable humidity with a lower chance of contamination was reported to be within 30–70% RH.<sup>3,4</sup> A humidity higher than 70% RH has been reported to result in contamination after sterilization.<sup>3,4</sup> Wet packages have the potential to attract microorganisms to enter the just-sterilized package and then recontaminate them.<sup>2</sup>

Our study revealed that the packages containing metal alone wrapped with nonwoven material or paper-film pouch had a humidity within the safety range of 30–70% RH immediately after removal from the sterilizing chamber. The humidity of packages containing any type of fabric contained moisture, as indicated by a higher intrapackage humidity. The presence of green hospital cotton fabric slowed down the rate of vaporization of moisture from the packages as demonstrated by a higher intrapackage humidity at later time points.

Thailand CSSA guidelines recommend that packages should not contain different types of instruments.<sup>6</sup> Loading fabrics together with metal instruments increases density inside the package, which can lead to residual humidity. Besides, the type of textile and the size of the loaded fabric may affect the moisture content and retention. Packages containing green hospital cotton fabric demonstrated a higher intrapackage humidity than those with a towel. This was apparent immediately after removal from the sterilization machine and after 15 minutes. In this study, cotton fabric was larger in size, less in porosity, and fabricated with more threads and heavy woven than towels. Moreover, several studies have reported that cotton has the worst wicking effect, which means this fabric is hard to

Fig. 3: Percent humidity of four different loads wrapped with three different types of wrapping materials measured immediately after removal from the sterilizing chamber. \*\*Statistically significant difference with  $p < 0.01$

$46.50 \pm 5.61$  and  $62.49 \pm 15.25\%$ , respectively (Fig. 3). The packages containing metal instruments alone wrapped with cotton fabric retained intrapackage humidity compared with nonwoven materials or paper-film pouch. Regardless of the type of packaging material, the packages containing fabrics retained a humidity higher than 70% when measured immediately after their removal from the sterilizing chamber (Fig. 3).

## DISCUSSION

Preparing packages of medical and dental instruments is an important step for a successful sterilization process. Despite the integrity of packaging material, the humidity of the package is a critical factor that affects the longevity of the packages when stored on the shelf. Our study demonstrated that the content

let moisture evaporate.<sup>7,8</sup> This property of cotton was consistent with the study of Su et al.<sup>9</sup> This revealed lower diffusion and drying rate of water, as well as higher water absorption rate in higher cotton content. Nowadays, wrapping of medical devices using nonwoven materials is popular worldwide. This might be due to its suitable properties, higher vapor transmission, liquid repellency, impermeability, and good recontamination control. Some infection control experts noted that one should not use cloth as a sterilization wrapping material because it cannot resist microbe penetration. The recommended sterilization packaging materials could be just nonwoven materials, paper-film pouches, and wrapped perforated cassette.<sup>10</sup>

A wet package after steam sterilization is identified as major failure. Several factors causing wet packaging include supersaturated steam, problems with the steam valve and internal content of loads. Wet packages can also result from less drying time. After a complete cycle of steam sterilization, the packages should be left for drying and cooling for 30 minutes. During this period, the sterile packages should not be touched or placed in an area prone to contamination, such as a busy trafficking area of room.<sup>6</sup> Moreover, the number of packages put in the sterilizing chamber is also critical. Too crowded loads prevent moisture removal from the sterilizing chamber and therefore affect intrapackage humidity.

## CONCLUSION

Packages that contained cotton fabric together with metal instruments retained a relatively high intrapackage humidity thus representing sterilization failure. Inclusion of cotton fabric in a package of metal instruments should be avoided. Wrapping with nonwoven material and paper-film pouch promotes a better evaporation of steam and results in a lower intrapackage humidity.

## CLINICAL SIGNIFICANCE

Our data provided indirect evidence to support that cotton fabric should not be included in the package of metal instruments for steam sterilization in routine dental instrument process.

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